PROCEEDINGS
OF THE
NATIONAL ACADEMY OF SCIENCES
Volume 5 MAY 15, 1919 Number 5

*SUPERPOSED OR DUPLICATED SPECTRUM FRINGES**

By Carl Barus
Department of Physics, Brown University

Communicated, February 17, 1919

1. *Introductory.*—To obtain sharp spectrum fringes it is necessary, as a rule, to use a slit narrow enough to show the Fraunhofer lines. Hence there is sometimes a deficiency of light from this reason alone. It occurred to me on producing identical fringes of inclination (achromatics or monochromatics) and of color (dispersion), that by their superposition a slit of any width (or an entire absence of slit) would be admissible, without destroying the fringes in the impure spectrum resulting.

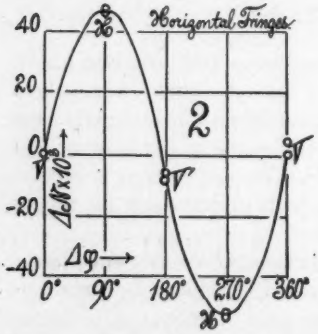
Furthermore if the edge of the prism is rotated around the axis of the spectro-telescope 180°, the inclination of all spectrum fringes must be symmetrically reversed; i.e., inclination up toward the right (positive) will become inclination down on the right (negative) to the same amount. The identical result may also be reached independently by displacing one of the mirrors of the interferometer parallel to itself (path difference) until the fringes passing through their maximum size reach the opposed inclination and size. Hence there must be a relation of a periodic kind between the displacement of mirror (ΔN) and rotation of the spectro-telescope ($\Delta\varphi$), by which sharpness of fringes in the absence of a slit is conditioned.

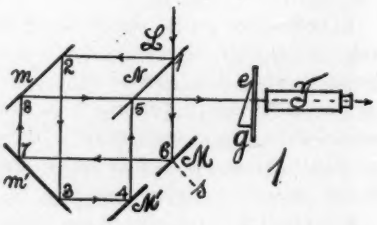
This device of locating an angle of rotation of the telescope by sharpness of fringes, may possibly be used for other purposes something after the manner of the halfshade or the sensitive tint; for if small, they jump suddenly out of an intensely brilliant unbroken spectrum band, when a definite $\Delta\varphi$ is reached.

Finally, as the fringes are examples of interference of intense non-reversed spectra, they should be available in such experiments as described in my last paper, for instance.

*Advance account, from a Report to the Carnegie Institution of Washington.

2. *Apparatus.*—To fix the ideas it will be necessary to give a diagram of the apparatus (fig. 1) employed. It is the selfadjusting interferometer, very serviceable here because of the large number of separate adjustments to be made, each of which might otherwise require long searching for fringes. White light L from a collimator takes the paths 12345T and 16785T, N being a halfsilver. The telescope T is provided with the direct vision grating g, capable of rotating around the axis 5T (angle $\Delta\varphi$). T and g are preferably rotated together, as a rigid system. The mirror MM' consists of two independent, nearly coplanar parts, as shown, one of which, M for instance, may be displaced parallel to itself by the micrometer screw along the normal s (displacement ΔN). Path difference to the amount $2\,\Delta N \cos 45°$ is thus introduced more than sufficient to pass the spectrum fringes through their maximum sizes between extremes of hair lines. By rotating m on a horizontal axis and m and M' on vertical axes, fringes of all sizes and inclinations when at their maximum may be obtained. The character of the





fringes due to inclination is shown by the achromatics and hence the adjustment is made with reference to them. They depart but little, relatively speaking, from their slope throughout the experiment.

3. *Observations.*—For the present purposes, the case of achromatic fringes, horizontal, vertical, and at about 45°, respectively, will suffice. Moreover, relatively small fringes, requiring much larger displacements (ΔN) than very large fringes, will generally be preferable.

Figure 2 gives an example of the results for horizontal achromatic or monochromatic fringes, the ordinates showing the displacement of micrometer ΔN (at M fig. 1) in 10^{-3} cm., and the abscissas the corresponding rotation of spectro-telescope (gT, fig. 1), needed to produce sharp fringes in the spectrum of an indefinitely wide slit. When the fringes are small, a few degrees of excessive rotation $\Delta\varphi$, either way, will cause them to vanish completely, so that the orientation for sharp fringes is quite sensitive. The symbols H (horizontal) and V (vertical) refer to the orientation of the edge of the prism, or the lines of the grating. The plane of dispersion is thus normal to H and V.

Hence it appears that horizontal fringes are left unchanged when the plane of dispersion is horizontal (edge of prism vertical), which is to be expected; for in such a case the light is permanently absent at the absorption bands due to the inclination fringes. On the other hand when the plane of dispersion is vertical, the nearly horizontal fringes have to pass from the positive to the negative inclination through their maximum size, when the telescope is rotated over 180°, and hence ΔN is very large, particularly so when the fringes are relatively small. In this large displacement of mirror ($\Delta N = .10$ cm., nearly) small monochromatic fringes will not change their inclination much; but their size will change considerably, and thus at $\Delta\varphi = 90°$ they are large and at $\Delta\varphi = 270°$, small.

Exactly the opposite conditions are met with when the fringes are nearly vertical, and the data may be omitted here. In figure 2, V' lies somewhat below V, as I could not (for incidental reasons) obtain adequately horizontal fringes without extreme difficulty. But this amounts merely to a slight shift of phase in the diagram. The vertical fringes were larger and hence a smaller double amplitude of displacement ($\Delta N = .07$ cm.) was here recorded.

Finally in the results for achromatic fringes at about 45° (estimated by the eye) the maxima were somewhere near $\Delta\varphi = 45°$ and 135°. Though the results were less smooth here, from deficiencies in the orientation (45°) of the achromatics, there was no fault to be found with the clearness of fringes, or with their abrupt evanescence.

If the spectrotelescope Tg (fig. 1) with a very fine slit is rotated, the fringes remain parallel to the length of the spectrum passing through a symmetrical case where the spectrum is reduced to a single fine colored line parallel to the slit. The fringes remain nearly parallel to the edge of the prism. Hence if any form coincides with the achromatic or monochromatic fringes, it will be retained on opening the slit wide, whereas the other forms, inasmuch as they require a fine slit, will vanish with the Fraunhofer lines. In the absence of a slit, the whole colored field bursts into sharp fringes, whenever the proper angle $\Delta\varphi$ of the telescope is reached. If the slit is a little too broad to show the solar lines distinctly, the monochromatic fringes may often be detected crosshatching the vague Fraunhofer lines, even when the spectrum fringes are still strong.

If the fringes of a fine slit are at say 45° to the axis, their inclination will change to 135° on passing the symmetrical stage; but there is apt to be both a change of size and angle in such cases.

Summary.—It has been shown in the experiments that the fringes (monochromatic) due to differences of inclination of rays, and the fringes (dispersion) resulting from differences in wave length of rays may be made of nearly equal size by displacing any mirror of the rectangular interferometer normal to itself (ΔN). The fringes will not, however, generally have the same inclination. This may be imparted to the spectrum fringes by rotating the spec-

tro-telescope (prism edge) on its axis until the inclinations also coincide. In reality the phenomenon is more complicated as the spectrum fringes change both size and inclination on rotation of the spectrum. In case of the completion of this twofold adjustment the slit of the collimator may be made indefinitely wide or removed altogether (undesirable light is to be screened off). The spectrum fringes may thus be given any intensity of illumination at pleasure, while the wave length corresponding to any fringe may be found by narrowing the slit until the Fraunhofer lines reappear. When the fringes are small the orientation of the spectro-telescope revolving around its axis may be determined by the appearance and evanescence of fringes. On the other hand the spectro-fringes, particularly if large, remain clearly enough in the field for the observation of the motion of a large number (i.e., for interferometry), before they vanish.

Similar results were obtained in broadening the vertical string of interference beads of reversed spectra. An account of these experiments will have to be omitted here, as they are much more complicated.

AN ELECTROMAGNETIC HYPOTHESIS OF THE KINETICS OF HETEROGENEOUS EQUILIBRIUM, AND OF THE STRUCTURE OF LIQUIDS

By William D. Harkins

Kent Chemical Laboratory, University of Chicago

Communicated by J. Stieglitz, March 24, 1919

While Gibbs,[1] in his remarkable treatise "On the Equilibrium of Heterogeneous Substances" has given a very broad treatment of his subject from the thermodynamic standpoint, nothing is included which would give any idea of the probable distribution of a component between a set of phases from a knowledge of the properties of only the pure component and of those of the phases before any of this component has been added to them. It is the purpose of this paper to indicate that the general nature of such a distribution can be predicted in most cases from the standpoint of the hypothesis that it is determined mainly by the intensity and nature of the electromagnetic field surrounding the molecules, and by the motion of the molecules and atoms. There is considerable evidence that the atom consists of a positively charged nucleus surrounded by a system of negative electrons. On such a basis it is to be expected that the atom, and therefore the molecule, would be surrounded by an electrostatic field. Inasmuch as there is much evidence from the magnetic properties of substances that the electrons are in motion, this is also to be considered as a magnetic field. Such a composite field is usually said to be electromagnetic.[2]

That the application of this hypothesis is not a single problem, is indicated by the electrical duality of such a field, and by the fact that while a part of the combinations between atoms or molecules in such a system may be of the nature of primary valence unions,—presumably a fitting of one or more of the outer electrons of one atom into the electronic system of another atom,—other molecules may be grouped together, though very much less firmly, by forces which still remain after all of the primary valence combinations have been made. In this preliminary paper only the more general features of the hypothesis will be considered,—that is only those which can be treated on the basis of a general knowledge of the intensity of the electromagnetic field around the molecule. The greatest obstacle in this connection is the meagerness of our knowledge of the characteristics of this field, which in this paper will be designated as the *stray field* of the molecule, since it gets out beyond the electronic constituents of the molecule.

The first problem which will be considered is: given two components (A) and (B), each in a phase by itself and both phases in the liquid state at the common temperature (T), when will these two phases be miscible and when will they be practically insoluble in each other? The relation is not difficult to find, for we know that (A) mixes with itself; so perfect miscibility should result when the stray fields around the molecules of (B) are sufficiently like those around the molecules of (A). Likeness of the fields in this sense means likeness in intensity, and presumably in the rate at which this intensity falls off with the distance from the molecule. A sufficient likeness of stray fields is also the condition which must hold if Raoult's law

$$p_A = P_A \frac{N_A}{N_A + N_B} = P_A x_A, \qquad p_B = P_B \frac{N_B}{N_A + N_B} = P_B x_B$$

is to be valid. Here p_A and p_B are the vapor pressures of (A) and (B) in the mixture, P_A and P_B are the vapor pressures of the pure liquids, and x_A and x_B are the mol fractions in the mixture. If (A) is a liquid, but the state of (B) is unknown, then (B) is apt to be a liquid if the pressures and temperatures of both are the same, though the size of the molecule is a factor which also has an effect. If the stray fields around the molecules of (A) and (B) are sufficiently different, then the two substances will be practically insoluble in each other—if the difference is extreme, one of the substances will be a gas and the other a solid, if they are at ordinary room temperatures.

Since the intensity of the stray field falls off more rapidly with the distance in the case of some molecules than with others (it probably decreases more rapidly around small *atoms* than around large atoms), it is not possible to give a list arranged in the order of increasing intensity of the stray field which is correct in all respects. Thus, while the intensity of the field close to the atoms of the heavy metals is very high, it undoubtedly decreases rapidly with the distance. On the other hand there are facts which seem to indicate

that the forces around the oxygen or nitrogen atoms of organic compounds or of water, or such atoms as are commonly called 'polar,' extend to a greater distance, although their intensity is less at the ordinary atomic distances. However, the following list may be considered to give something of this order of increasing intensity for a limited number of substances. This list has been obtained for the most part from a consideration of the *surface tension relations* of substances, and is as follows, beginning with those substances around whose molecules the stray field is weakest: helium, neon, hydrogen (molecular, not atomic), argon, krypton, xenon, nitrogen, oxygen, methane, carbon monoxide, and the following organic compounds—saturated aliphatic hydrocarbons, aromatic hydrocarbons, sulphides, mercaptans, halogen derivatives (methyl chloride, carbon tetrachloride, chloroform, and ethylene chloride, with rapidly increasing fields), unsaturated hydrocarbons, ethers, esters, nitro compounds, nitriles, aldehydes, ketones, alcohols, amines, acids, and unsaturated acids. Following these are water, molten salts, heavy metals, boron, and carbon. The list of organic substances is arranged for derivatives with short hydrocarbon chains. A lengthening of the chain causes a displacement in the direction of lower intensity for polar derivatives, but probably toward higher intensity in the case of the hydrocarbons themselves. It will be seen that in general the greater the distance between the substances in this list, the less their solubility in each other, the closer together, the more soluble. For organic substances, though the present list is much more extensive, it is in agreement with that found by Rothmund from solubility data.[3] It is well known that metals in general give concentrated solutions only with metals, carbon, and other similar substances; molten salts dissolve salts or water; pairs of organic liquids are miscible unless the members of the pair lie at the very opposite extreme of the list of organic substances; water dissolves salts or organic substances which are close to it in the list. An interesting illustration of this relation is given by data on the organic halogen derivatives listed above. The solubility of carbon tetrachloride per 100 grams of water is 0.80 grams, while that of chloroform, which lies closer to water, is 0.822 grams; and methylene chloride, approaching water still more closely, has a solubility of 2.00 grams. This is also the order of increasing hydrogen content of the molecule, but that this is not the determining factor is indicated by the fact that methyl chloride and methane, similar compounds containing still more hydrogen, are much less soluble in water. In organic compounds the intensity of the stray field is much higher adjacent to what are commonly called double bonds, than it is near single bonds, and this intensity grows much larger still if triple bonds are introduced. Corresponding to this the solubility of ethane, with its single bond between two carbon atoms, is 0.0507 volumes of gas per volume of liquid; that of ethylene with its double bond is 0.1311, or more than twice as great; while acetylene with its triple bond has a solubility of 1.105, or about 22 times more than that of the single bonded compound.

The above list, giving the order of intensity of the stray electromagnetic fields, will be seen to give the substances in increasing order of cohesion. The atoms or molecules giving the lowest cohesion, such as He, Ne, A, Kr, Xe, etc., are just those which, according to the valence theory of G. N. Lewis (*J. Amer. Chem. Soc.*, **38,** 1916, (762–85)) have *complete* outer shells of eletrons (2 for He, 8 for Ne and A). The substances with the highest cohesion, such as carbon, silicon, iron and cobalt, ruthenium, and tungsten and osmium, are elements which lie in the periodic system exactly half way between the elements of lowest cohesion, so high cohesion may be said to result when the outer shell of electrons is half filled or half complete. In other words a low stray field is found when according to the theory of Lewis the atomic or molecular outer shell of electrons is complete, the highest stray field, when the shell is half filled, that is when there is the possibility of the greatest number of electronic linkages directly between the atoms, without the intermediate formation of molecules of a simple type containing only a few atoms. Accompanying a high field the substance is found to have a low atomic volume, a high cohesion, melting point, a low coefficient of expansion, a low compressibility, etc. When the field is low in intensity, the properties are just the opposite.

In analyzing a solubility problem it is well to consider the attraction between the molecules of (A), between those of (B), and also that between (A) and (B). Consider octane and water which are mutually insoluble. It has sometimes been considered that this insolubility is due to the fact that water molecules attract each other more than they do molecules of octane, and that octane molecules attract each other more than they do molecules of water. Now the work of this laboratory shows that while the molecules of water do attract each other much more than those of octane, on the other hand the molecules of octane attract those of water very slightly more than they do those of octane. The much greater attraction of the water molecules for each other is a sufficient cause to produce immiscibility, since it is only necessary that when a group of water molecules is once formed, the mutual attraction shall be great enough to cause the molecules of water to leave the group less often than they enter it, so long as there is an appreciable quantity of water in the octane. The octane molecules are thus left in a phase by themselves.

Since an increase in the intensity of the stray field around the molecule is accompanied by an increase in molecular attraction, it causes an increase in the cohesion of the liquid or of the solid, so in its application to pure liquids the above theory gives predictions which are similar to those obtained by that of Hildebrand,[4] that liquids of like cohesions are miscible, while those whose cohesions are very unlike are practically insoluble in each other. However, solubility is a molecular scale phenomenon, so there are certain advantages of a molecular theory of the phenomenon. Moreover, the theory presented

here has a much wider range of application, since it may be used to indicate the internal structure of a liquid, to predict the distribution (partition and adsorption) of components between different phases, interfaces, and surfaces (these will be designated by the term *regions*), and is of great importance in theories of ideal and non-ideal solutions:—in other words it is a theory of what is called by Washburn[5] the '*thermodynamic environment.*' This in the sense of our theory would be designated as the *electromagnetic environment.*

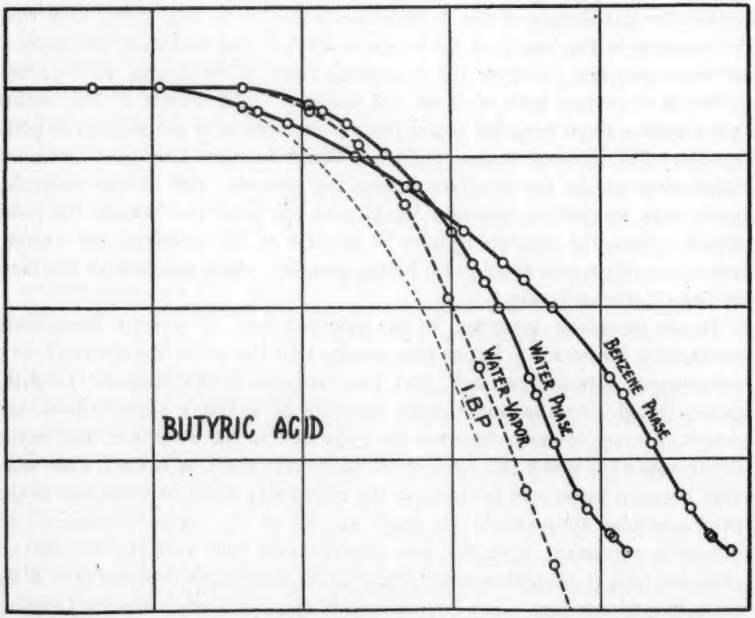
Application to Interfaces and to Distribution between Regions.—While in applying the hypothesis, the intensity of the stray fields around the molecules is of primary importance, at least one additional principle must be used if the direction which any change will take by itself is to be predicted. As might be expected the second law of thermodynamics is of fundamental importance in this connection, and for this purpose it may be stated in the form: Any change which takes place by itself in a system will proceed in the direction which will result in a decrease in the free energy of the system. Thus a surface will decrease in area by itself, but will not increase. Since a rapid variation of the intensity of the stray field with the distance in any direction, is accompanied by a high concentration of free energy, the second law indicates that in any change which takes place by itself, the variation in the stray field becomes less abrupt. If we imagine the surface of a liquid up to a bounding, surface plane, to have just the same structure as the interior of the liquid, then the actual surface always has a smaller free energy[6] than would be given by calculation for this imaginary surface, and therefore the drop in intensity of the stray electromagnetic field at the actual surface is always less than it would be at a surface of the structure of the imaginary surface. Since a molecule is often made up of several species of atoms, the stray field around it is often unsymmetrical. Thus many organic molecules, such as the primary normal alcohols, acids, amines, nitro compounds, nitriles, ethylene and acetylene derivatives, etc., consist of a paraffin chain around which the stray field has a relatively low intensity (a so-called non-polar group), while at the other end of the molecule there is a group containing oxygen or nitrogen, sometimes with metals in addition, around which the intensity of the stray field is relatively high (a polar group). Such molecules may be designated as *polar-nonpolar*, and designated by the symbol o——, where o represents the polar, and —— the nonpolar end of the molecule. If molecules of this type, such as butyric acid (C_3H_7COOH), are put in a two phase system consisting of a polar liquid such as water, and a nonpolar liquid such as octane, then the free energy of the interface will be less when the transition from one liquid to the other is made by molecules of butyric acid, with their polar ends turned toward the water, and their nonpolar ends turned toward the octane, since in this way the abruptness of the transition is decreased.

The problem here arises as to the distribution of molecules of the polar-nonpolar type between the two liquid phases, their surfaces, and the interface

between them. It may be considered that each region (phase, surface, or interface) exerts a certain restraining force upon (has affinity for) the solute molecules. Since at equilibrium the thermodynamic potential of the solute is the same in all of the regions, it may be considered that the concentration of the solute (at equilibrium) in each phase, interface or surface, gives an index of the restraining force exerted by that region upon the solute molecules. Let us now assume that we have a number of exactly similar two phase systems, each of which consists of equal volumes of a polar liquid, such as water, and a nonpolar liquid such as octane, with an interface of a definite area between them, and into each of these systems we put N molecules of the polar-nonpolar type o——. The hypothesis indicates that with a given polar group the distribution of the N molecules will vary in such a way that with an increase in the length of the nonpolar part of the molecule, the number of molecules, and therefore the restraining force in the octane will increase, while in the water both of these will decrease. The reverse of this occurs when with a given nonpolar chain, there is an increase in the number of polar groups. The greatest restraining force would be exerted on such molecules when they are in the interface, where the nonpolar end of the molecules could turn toward the nonpolar liquid, and the polar end toward the polar liquid. Since the restraining force is greatest at the interface, the concentration in this region should also be the greatest, which agrees with the facts as found by experiment.

In the preceding paragraph it was assumed that the water is completely covered by the octane. Let us now assume that the water has a surface, or a water-vapor interface as well, and that benzene is the nonpolar (slightly polar) liquid. At the water-vapor interface at ordinary temperatures, the drop in average intensity between the stray field in the water and that in the dilute vapor (in which the intensity is practically zero), is much greater than that between water and benzene, so the restraining force on molecules of the polar-nonpolar type should be much greater at the former interface. In complete agreement with this idea experimental tests indicate that *the restraining force is about three times greater at the water-vapor interface than at the water-benzene interface*, when butyric acid is the solute, and somewhat similar results are obtained when the solute is acetic acid. The experimental work was carried out in 1913 by E. C. Humphrey, and was afterward repeated and made more precise by H. H. King and H. McLaughlin. The above results may be expressed in other words as follows: the thermodynamic potential of butyric acid is about three times as great in the water-benzene interface as it is in a water surface, when the concentration of the butyric acid in both of these interfaces is the same, or the drop in mechanical potential which a molecule of butyric acid undergoes in passing from water into the interface is much greater when the second phase is a dilute vapor than it is when the second phase is a nonpolar liquid. This is an illustration of a general case,

and similar relations hold for any molecule of the polar-nonpolar type with reference to the pair of interfaces, polar liquid-vapor, and polar liquid-less polar liquid. Similar work is now in progress, a metal being used as one of the phases, and vapor, water, or an organic liquid as the other. The results of this work are very interesting, but space is wanting for their discussion. They indicate that, corresponding to the greater drop in intensity of the stray field between metal and vapor, in comparison with that between water and vapor, the adsorption at the metallic surface is much greater than that at a water surface for the same concentration of the adsorbed component in the nonmetallic phase.



A striking result obtained was that the number of molecules per square centimeter in the 'constant concentration' film between water and benzene was found to be 2.79×10^{14}, while that between water and air was found to contain 2.77×10^{14} molecules, showing that the number of molecules in such a film is independent of the presence of the second liquid phase, and therefore depends only on the dimensions of the molecules.

These results were obtained by the drop weight and capillary height methods for determining surface tension, as they have been developed in this laboratory.[7] For such work a high degree of precision is essential. The results for butyric acid are presented in a graphic form in Figure 1, where

the ordinates give the surface tension; the abscissae, the logarithm of the concentration, and the adsorption is obtained from the slope of the respective curve by means of the Gibbs equation, $\mu = \frac{1}{iRT}\frac{d\gamma}{d\ln c}$ where μ is the adsorption, γ is the surface tension, and c is the concentration of the solute. The curve for the water-vapor interface lies to the left of that for the water phase of the two phase system, which indicates that the restraining force of the former interface is the higher. The curve marked I. B. P. represents that which would be obtained for the benzene of the two phase system if the butyric acid in this phase were not associated. The horizontal distance between this curve and that for the actual benzene phase is a measure of the degree of association.

When applied to the structure of a liquid our hypothesis indicates that when the molecules are not wholly symmetrical, there will be more or less grouping of the parts of the molecules around which the stray field is the most intense, the extent of the grouping being a function of the temperature also. It is probable that liquids of this class have more, but a less definite, structure than is commonly supposed. If molecules of the polar-nonpolar type are dissolved in a nonpolar liquid this grouping is commonly spoken of as association of the solute; in a polar solvent it is considered as the solvation or hydration of the solute, in pure liquids it is designated as the association of the liquid. These groupings are constantly being modified by the kinetic agitation, the other factors being the intensity of the stray field, and the space available for the grouping.

A discussion of electrical theories of surface phenomena will be found in papers by Hardy;[8] Langmuir;[9] Harkins, Brown, and Davies;[10] Harkins, Davies and Clark,[11] and by Frenkel.[12] The present paper will be published in a much more complete form in the Journal of the American Chemical Society, in which there will be taken up the question of what is known as specific adsorption.

[1] Gibbs, *Trans. Conn. Acad., New Haven*, Oct. 1875–May 1876, (108–248), and May 1877–July 1878, (343–524).

[2] Lewis, Wm. Mc., *Phil. Mag., London*, **28**, 1914, (104–16).

[3] Rothmund, *Loslichkeit und Loslichkeitsbeeinflussigung*, Leipzig, 1907, p. 118.

[4] Hildebrand, *J. Amer. Chem. Soc., Easton, Pa.*, **38**, 1916, (1452–73).

[5] Washburn, *Physical Chemistry*, Chapter XIII, pp. 134–42, also pp. 143, 224, 273.

[6] Harkins, Davies, and Clark, *J. Am. Chem. Soc.*, **39**, 1917, (553–70, 594–5).

[7] Harkins and Humphrey, *Ibid.*, **38**, 1916, (228–46); Harkins and Brown, *Ibid.*, **38**, 1916, (246–52), and April 1919.

[8] Hardy, *London, Proc. Roy. Soc., B*, **86**, 1911–12, (634).

[9] Langmuir, *J. Amer. Chem. Soc.*, **39**, 1917, (1848–1906); these PROCEEDINGS, **3**, 1917, (251–7). Abstract in *Met Chem. Eng.* **15**, 1916, (468).

[10] Harkins, Brown, and Davies, *Ibid.*, **39**, 1917, (354–64).

[11] Harkins, Davies, and Clark, loc. cit., 1917, (541–96).

[12] Frenkel, *Phil. Mag., London*, **33**, 1917, (297–322).

HYDROGEN OVERVOLTAGE

By Duncan A. MacInnes and Leon Adler

Chemistry Department, University of Illinois

Communicated by W. A. Noyes, March 29, 1919

Hydrogen overvoltage may be defined as the difference of potential that exists between a reversible hydrogen electrode, and an electrode, in the same solution, at which hydrogen, H_2, is being formed from hydrogen ions. A reversible hydrogen electrode is one at which the reaction

$$2H^+ + 2\epsilon = H_2 \qquad (1)$$

(ϵ = electron) has reached equilibrium. This equilibrium is attained, and maintained during the passage of very small currents, only on electrodes covered with a dispersed 'noble' metal, such as platinum. If stronger currents are passed across such a metal-electrolyte boundary, or if other electrodes are used, the reaction does not take place under equilibrium conditions and an overvoltage appears. For instance, it requires an overvoltage of about 0.2 volt to liberate hydrogen gas from a polished platinum surface, and about 0.7 volt from a lead surface.

On attempting to determine the overvoltage of small electrodes of 'platinized' platinum the authors observed some interesting fluctuations in the measured voltage, a typical series of measurements being plotted in figure 1. Here ordinates represent overvoltage in millivolts and abscissae time in seconds. Bubbles were evolved at the points marked by small circles, there being one bubble to each fluctuation. At the low current densities used, the bubbles came off at a single point on the electrode, making it appear probable that the nucleus of the next bubble remained on the electrode after each bubble had separated.

When Reaction 1 takes place it is probable that the greater part of the liberated hydrogen goes directly into solution. Unless carried away by diffusion, stirring, or other means, the concentration of dissolved hydrogen, in immediate contact with the electrode, will tend to rise and produce a supersaturated solution. It is this layer of dissolved hydrogen that is responsible for the overvoltage. However, if there is a nucleus of *gaseous* hydrogen on the electrode a portion of the liberated hydrogen will enter this gaseous phase. A gaseous nucleus will thus play a similar rôle to that of a small crystal in a supersaturated salt solution. It is evident that hydrogen gas in the form of small bubbles must have a larger energy content, per mol of gas, than the same volume of undispersed gas, as energy must be expended in overcoming the surface tension in the formation of the bubbles. Such bubbles will be more soluble (i.e., remain at equilibrium with more concentrated dissolved hydrogen) than the undispersed gas. This is analogous to

the increase of solubility produced by the fine grinding of solids. An electrode in equilibrium with small bubbles will thus reach a higher potential than one in contact with undispersed gas.

With the foregoing in mind we can proceed to an explanation of the voltage fluctuations. At a (fig. 1) a bubble has separated from the electrode, leaving a nucleus behind. As the electrolysis proceeds this nucleus will grow, obtaining hydrogen from the supersaturated solution or from the electrode. However, as the nucleus increases in size, the energy necessary to produce further increases in volume must decrease, as the ratio

$$\frac{\text{increase in surface}}{\text{increase in volume}}$$

is continuously decreasing. If the bubble is growing slowly the hydrogen bearing solution surrounding the electrode will tend to get into equilibrium with the bubble. This accounts for the decrease in overvoltage from a to b.

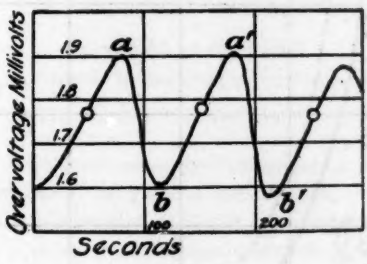


FIG. 1

At b the buoyant effect of the electrolyte is sufficient to overcome the attraction of the electrode for the bubble, which breaks away, leaving a nucleus behind. Bubbles are, however, seldom observed to come off at points corresponding to b; they probably remain in the pores of the electrode, and are pushed out by the growth of the following bubble. From b to a' the concentration of dissolved hydrogen is increasing to a value such that the nucleus can again grow, when the processes described above are repeated.

It is evident that it makes no difference, in so far as the absorption of energy is concerned, whether small bubbles are evolved, or a solution of hydrogen in equilibrium with the bubbles is formed. In the following paragraph it is assumed that all the hydrogen is liberated as bubbles.

The number of bubbles of radius r that can be formed from a mol of hydrogen of volume V is $3V/4\pi r^3$. To obtain the surface energy of such a system this must be multiplied by $4\pi r^2$ and the surface tension γ. Substituting RT/p for V (R, T and p are the gas constant, the absolute temperature and the pressure respectively) and equating the surface energy with the electrical

energy, $2FE$, in which F is the Faraday equivalent and E the overvoltage, we obtain:

$$2FE = \frac{4\pi r^2 RT}{4/3\pi r^3 p}\gamma = \frac{3RT}{pr}\gamma \qquad (2)$$

Substituting 75.6 dynes per sq. cm. for γ and appropriate values for the other terms, equation 4 becomes, for 25°C. and one atmosphere

$$E = \frac{2.87 \times 10^{-2}}{4}. \qquad (3)$$

For platinized platinum electrodes this relation was found to hold quantitively. For instance, in one experiment the bubbles were found to have

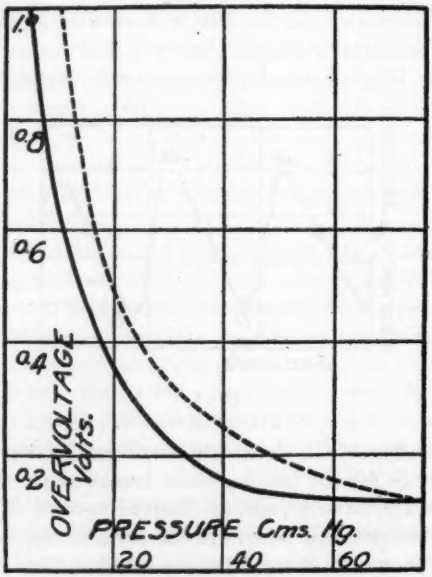


FIG. 2

radii of 0.017 mm., corresponding to an overvoltage of 1.6 mv. The observed values fluctuated between 1.9 and 1.6 mv. the latter potential, according to the theory, being that corresponding to the fully formed bubble. For electrodes of other metals difficulty was encountered in measuring the bubbles, but they were found to be smaller than those for platinized platinum in all cases observed.

If the bubble radius does not change with the pressure (as was found to be the case, up to 16 atm. pressure, with platinized platinum electrodes) the overvoltage (according to equation 2) should increase as the pressure decreases, and *vice versa*. This prediction was found to be verified in some

unpublished work by Goodwin and Wilson of the Massachusetts Institute of Technology. In figure 2 the solid line shows the experimentally determined variation with the pressure of the overvoltage of nickel. Similar curves were found for mercury and lead. The dotted line shows the variation as calculated by Equation 2, using the overvoltage at one atmosphere as a basis for computing the values for the other pressures. The difference between these two curves may be explained by an increase of stirring at the lower pressures, since many more bubbles are produced per mol of gas.

It appears quite probable, then, that the factor that determines the overvoltage of an electrode at any one pressure is the size of the gaseous nuclei that can cling to it. A number of observers have called attention to the fact that electrodes with low overvoltages are those that have large adsorptive powers. This adsorptive power is undoubtedly related to the attraction of an electrode for a gaseous nucleus.

AN APPROXIMATE LAW OF ENERGY DISTRIBUTION IN THE GENERAL X-RAY SPECTRUM

By David L. Webster

Department of Physics, Massachusetts Institute of Technology

Communicated by E. H. Hall, April 9, 1919

In the spectra of X-rays as ordinarily determined there are factors of absorption in the anticathode, the glass of the tube, the reflecting crystal and the ionized gas, and of efficiency of reflection that are all functions of the frequency. Fortunately, except at the discontinuities of any of these absorptions, the unknown factors vary continuously with frequency, so that the measured intensities in the spectrum represent the energy distribution qualitatively, but by no means quantitatively. The problem of the present paper is to combine other available data in such a way as to find an approximate law of energy distribution, not involving unknown absorption factors, and avoiding also any *a priori* assumptions about the emitting mechanism. The data are incomplete and this work is merely a first approximation.

For data we have (a) some graphs of intensity against potential at constant frequency (where the unknown factors are all constant in each graph), and (b) the total energy measurements by Beatty,[1] who made the absorption negligible by using a thin window and no crystal. Some of the intensity-potential graphs were obtained in the course of experiments for another purpose with a rhodium target by the author,[2] and with platinum by the author and Dr. H. Clark,[3] and others were obtained by taking points at the same wave length from intensity-wave length graphs drawn for tungsten by A. W. Hull,[4] Hull and Rice[5] and Ulrey,[6] and for molybdenum by Hull.

In the experiments on rhodium and platinum, the spectrometer was kept at a fixed wave length and the potential was changed between readings.

This gave directly a series of intensity-potential graphs that are represented with fairly good accuracy by the law

$$I(V,\nu) = k(\nu)\left\{(V - H\nu) + H\nu p(\nu)\left(1 - e^{-q(\nu)\left(\frac{V}{H\nu}-1\right)}\right)\right\},$$

where $I(V,\nu)d\nu$ is the intensity in the frequency range $d\nu$ per electron striking the target from potential V, and H is the ratio of Planck's h to the charge of the electron, and $k(\nu)$, $p(\nu)$ and $q(\nu)$ are functions of ν. Since p and q are pure numbers they are independent of the arbitrary intensity unit, and can be determined wherever the data are available, though not very accurately because the term containing them is rather small. In the few data available for rhodium, p is of the order of 0.06 to 0.08 and q about 12 to 16, making pq about 1. The work on tungsten and molybdenum gives only a few points on each intensity potential graph, and because of the smallness of the exponential term and its disappearance at potentials large enough for really accurate intensity measurements, it is impossible to get an accurate test of this law except with more points than one can get from these graphs. But the data obtainable show that the relation between I and V is not far from linear, and the only definite curvature seems to be something of the type indicated by the above equation. In platinum, we have data scattered over the range from 1.33 to 0.43 Å, but most of them rather rough. But to an accuracy of 20 or 30%, they seem to indicate constant values for both p and q, with $p = 1/5$ and $q = 13$, so that $pq = 5/2$. Fortunately the smallness of the p and q terms makes their influence on the determination of k also small, although the existence of the terms themselves may be of considerable theoretical importance. For the present, therefore, we shall include these terms in the calculation, but neglect any changes of p and q with ν.

An important point to be deduced from the graphs of 'intensity' against ν is the fact that they are smooth and regular, so that k must have no discontinuities or sharp curvature in its graph against ν. As a trial value we shall therefore assume first that $k(\nu) = k\nu^n$, with k and n both constant. The total energy is then

$$E = \int_0^{\frac{V}{H}} I(V,\nu)d\nu = k\left\{\frac{1}{n+1} - \frac{1-p}{n+2} - p\int_0^1 x^{n+1} e^{-q\left(\frac{1}{x}-1\right)} dx\right\}\frac{V^{n+2}}{H^{n+1}},$$

If $k(\nu)$ is not expressible in this way, but as a power series in ν, then this equation gives a power series for E in terms of V, and if the coefficients for such a series are found experimentally those of the series for k can be computed from them. If E depends on a single power of V, then k must depend on a single power of ν.

Now, Beatty's work indicates that E = constant $\times V^2$. Hence, we infer that $n = 0$ and $k(\nu) = k$ = constant, and

$$E = k\left\{\frac{1}{2} + \frac{p}{2} - p\int_0^1 xe^{-q\left(\frac{1}{x}-1\right)}\,dx\right\}\frac{V^2}{H},$$

or approximately

$$E = k\left\{\frac{1}{2} + \frac{p}{2} - \frac{p}{q}\right\}\frac{V^2}{H}.$$

In a previous paper by the author[7] it was shown that, neglecting absorption in the target, the intensity per electron and per atom and per unit interval of frequency from an extremely thin target would be

$$i(V, \nu) = \frac{bD_V I(V,\nu)}{2NV},$$

where b is the coefficient of the Thomson-Whiddington law in the form $V_0^2 - V_x^2 = bx$, and N is the number of atoms struck per unit length of the electrons' path. This equation is of course subject to some error due to absorption in the target, and as one may readily prove, could be corrected by adding to i a term

$$\frac{a\mu}{N} I(V, \nu),$$

where a is the ratio of the distance travelled in the target by the emerging X-rays to the distance travelled by the cathode ray before it emits X-rays, and μ is the linear absorption coefficient. This correction is important only at low frequencies. Neglecting it, we have

$$i(V, \nu) = \frac{bk}{2NV}\left\{1 + pqe^{-q\left(\frac{V}{H\nu}-1\right)}\right\},$$

with k, p and q all constant. It must be remembered that the data are very incomplete and this result is unreliable and is presented only for lack of anything better. But the true law must have something of the same general characteristics as this, and certain conclusions about the emitting mechanism can be drawn from that fact.

First, let us assume that some form of quantum law governs the radiation of frequencies different from V/H as well as at that one. We are then practically though not rigorously led to one of two alternatives. If the quantum law merely regulates the frequency being emitted at any instant in terms of the energy still available at that instant for radiation, so that the radiation by one electron is not monochromatic, then every electron radiating at all must radiate some energy at the highest possible frequency, V/H, and presumably give up all its energy to radiation. But this would make $i(V, \nu)$ independent of ν, and is therefore improbable. The more probable alternative is that the radiation by one electron is monochromatic, and the quantum law gives its

frequency in terms of the total energy radiated. In this case only a few of the electrons radiating will do so at frequencies very near the limit, V/H, though more will radiate there than in an equal frequency interval at a frequency not too far below that one. Adopting this conclusion, the chance that an electron radiates a fraction of its energy within a range ϵ to $\epsilon + d\epsilon$ is $f(V, \epsilon)d\epsilon$, where

$$f(V, \epsilon) = \frac{bk}{2Nh} \frac{1 + pqe^{-q\left(\frac{1}{\epsilon}-1\right)}}{V\epsilon}.$$

Let R be the radius of the atom and r the distance from the particle causing radiation to the path the electron would have taken if not deviated. Then

$$\frac{d(r^2)}{R^2} = -f(V, \epsilon)\, d\epsilon, \text{ with } \epsilon = 1 \text{ at } r = 0,$$

or

$$\frac{r^2}{R^2} = \int_{\epsilon}^{1} f(V, \epsilon)\, d\epsilon.$$

If we assumed the frequency to be determined by the energy transferred in a collision of two equal repelling particles, one of which was initially at rest, a definite value of ν could be predicted for any assumed values of r and V, and the forms of $f(V, \epsilon)$ and $i(V, \nu)$ could be found. Several such assumptions have been tried, but none give the forms of f and i required above. A detailed discussion would be out of place with such rough preliminary data, and any such assumption would be improbable, but it seems likely that more exact data of this type ought to throw valuable light on the mechanism of radiation. It is hoped that with apparatus now being constructed it will be possible to get such data.

[1] Beatty, R. T., *Proc. Roy. Soc., London*, A 89, 1913, (314–27).

[2] Webster, D. L., these PROCEEDINGS, 2, 1916, (90–4); *Physic. Rev., Ithaca*, 9, 1916, (599–613).

[3] Webster, D. L., and Clark, H., these PROCEEDINGS, 3, 1917, (181–5).

[4] Hull, A. W., *Amer. J. Roentgenology* 2, 1915, (893–9).

[5] Hull, A. W., and Rice, M., these PROCEEDINGS, 2, 1916, (265–70).

[6] Ulrey, C. T., *Physic. Rev., Ithaca*, 11, 1918, (401–10).

[7] Webster, D. L., *Ibid.*, 9, 1917, (220–5).

LINEAR ARRANGEMENT OF GENES AND DOUBLE CROSSING OVER

By Harold H. Plough

Department of Biology, Amherst College

Communicated by T. H. Morgan, April 11, 1919

In his recent criticism of the theory of linear arrangement of the genes in the chromosome, Prof. W. E. Castle states that that theory calls for a number of unproved secondary hypotheses, among which is the assumption of

TABLE 1

NUMBER	TEMPERATURE	TOTAL NUMBER	PER CENT CROSSOVERS	PER CENT INCREASE OVER CONTROL	PER CENT CROSSOVERS	PER CENT INCREASE OVER CONTROL
b pr c			b–pr		pr–c	
	deg. C.					
1	9.0	995	13.5	125	25.8	32
2	13.0	2,972	13.5	125	27.2	39
3	17.5	2,870	8.3	38	23.0	17
4 (Control)	22.0	15,000	6.0		19.6	
5	29.0	4,269	8.8	47	22.5	14
6	31.0	3,547	14.0	133	26.7	36
7	32.0	4,376	15.7	162	26.5	35
S^1 b c			S^1–b		b–c	
8 (Control)	22.0	6,009	38.4		21.1	
9	31.5	3,769	37.8	Decrease	33.2	58
b pr vg			b–pr		pr–vg	
10 (Control)	22.0	2,139	10.0		15.1	
11	31.5	1,099	15.1	50	20.2	34

Data from H. H. Plough, *J. Exp. Zool.*, **24**, No. 2.

double crossing over. There are, however, a number of facts, each independent of the original hypothesis, that require double crossing over in their explanation. Some time ago[1] I demonstrated that treatment of female flies with temperatures both above and below the 'normal' (20°–27°C.) resulted in an increase in the percentage of crossing over in the second chromosome. This increase for a short chromosome 'distance' was roughly proportional to the number of degrees above or below the 'normal.' Bridges[2] had already shown that age increased crossing over and more recently it has appeared probable that other environmental agents may cause a similar increase. In all cases, as pointed out in the original paper, the increase is much greater for short regions than for longer ones, and finally, for genes which normally

give a crossing over percentage of 35% or more no increase at all results. A summary of these facts extracted from my earlier paper is given below. The percentage of increase over the control is given. Only those data which were collected at the same time are entirely comparable with each other.

As a whole this table shows conclusively that small percentages of crossing over are increased markedly by high or low temperatures, while larger percentages show a much less significant increase. For instance, as a result of exposure of the F_1 females to 32°C. (no. 7 in the table) the crossing over value between black and purple was increased from 6 in the control to 15.7—an increase of 162%—while purple-curved in the same experiment showed an increase from 19.6 to 26.5 or only 35%. In no. 9 in the table it is shown that while the black-curved value was increased by 58% as a result of a temperature of 31.5°C., the value of the star to black region (38.4 units) not only did not increase, but actually showed a slight decrease. The amount of the increase is in all cases related to the crossover value involved. The last named case was explained in my former paper as follows (p. 157):

> The first brood data show very clearly that while the blackcurved region of the chromosome shows an unquestionable increase of more than 50%, no increase at all is registered in the test between star and black. This can mean only that with such long distances any increase in the actual amount of single crossing over is compensated by a similar increase in double crossing over, and thus no increase at all appears in the percentage registered by the count.

The data show that the percentage of increase caused by high or low temperature is roughly in inverse proportion to the size of the crossover value involved. On Castle's three dimensional scheme these facts necessitate the view that long chromosomal 'distances' are less affected by temperature than are short ones. On the hypothesis of linear arrangement this relation is consistently explained by the assumption that the amount of double crossing over is increased by high and by low temperatures.

[1] Plough, H. H., *J. Exp. Zool.*, **24**, 1917, (147).
[2] Bridges, C. B., *Ibid.*, **19**, 1915, (1).

THE SPATIAL RELATIONS OF GENES

By A. H. Sturtevant, C. B. Bridges, and T. H. Morgan

Columbia University and Carnegie Institution of Washington

Communicated April 11, 1919

Castle[1] has proposed an arrangement of linked genes in three dimensions, based on the assumption that the distance between any two loci is exactly proportional to the observed crossover value. He believes that this system gives a better agreement between observation and expectation than does the hypothesis of a strictly linear arrangement that we have developed.

According to Castle, "that the arrangement of the genes within a linkage system is strictly linear seems for a variety of reasons doubtful." The only one of these reasons specified is that "it is doubtful, for example, whether an elaborate organic molecule ever has a simple string-like form." The suggestion that chromosomes are organic molecules is probably not intended to be taken seriously. The further argument, that organic molecules probably never have a simple string-like form, is scarcely to the point, for *chromosomes* do have a thread-like form. The comparison between crossing over and organic substitution reactions seems forced, for these reasons, as well as on strictly chemical grounds.

Castle presents two cases as "critical" ones showing that the arrangement cannot be linear; viz., the relations of bifid and of abnormal to yellow and white. The case of abnormal presents some complications,[2] but bifid may be accepted as a crucial case. On the basis of the data summarized by Morgan and Bridges[3] and used by Castle, the crossover values for yellow, white and bifid are:

Yellow white	1.1
White bifid	5.3
Yellow bifid	5.5

Each of these values is based on several thousand flies, so that the probable errors arising from random sampling are small. Castle points out that no one of the three values is either the sum or the difference of the other two, and therefore concludes that the placing of the three loci in a line cannot represent their relations to each other. But these data come from several sources; and it has frequently been pointed out that crossover values are subject to variation, due to genetic factors,[4] to environmental causes,[5] or to differential viability.[6] In such a case as the present one, then, strictly comparable data can be obtained only from experiments in which all three loci are followed at the same time.[7] Such crucial data for yellow, white, and bifid had been given by Morgan and Bridges[3] and by Muller,[4] in papers which were known to Castle. These experiments may be summarized as follows:

	NON-CROSSOVERS	YELLOW SEPARATES FROM OTHER TWO	WHITE SEPARATES	BIFID SEPARATES	TOTAL
Morgan and Bridges	487	3	0	16	506
Muller	673	12	0	27	712
Total	1160	15	0	43	1218
Percentage		1.2	0.0	3.5	

Here we have crossover values that are strictly comparable with each other, and they show:

Yellow white	1.2
White bifid	3.5
Yellow bifid	4.7

These relations, in which the sum of the smaller values is exactly equal to the larger one, can be represented[8] only by placing the three loci in a straight line, in the order yellow, white, bifid.[9]

It will be seen that this linear arrangement is necessitated by the fact that white never separated from yellow and bifid; i.e., no 'double crossover' occurred. By considering data involving only short distances (e.g., white bifid club, bifid club vermilion, club vermilion miniature, vermilion miniature sable, sable rudimentary forked, rudimentary forked bar, and forked bar fused; or still better, certain unpublished data including the loci ruby, cut, tan, garnet, etc.), it is possible to handle the whole X-chromosome of Drosophila as made up of successive overlapping sections in which double crossing over either does not occur or is so rare as to be negligible. Since these sections must be represented as straight lines, and since they overlap, the whole X-chromosome must be represented as a straight line.

For longer sections of this same chromosome, however, double crossovers do occur, so that the distances apart on the straight line are no longer proportional to the crossover values. The 'map-distance' for white forked, for example, is 55.4, though the crossover value observed[10] is 43.9.

Castle is disturbed by such map distances greater than 50. He says: "A crossover value greater than fifty cannot exist. For there must be either linkage or no-linkage. But no-linkage means 50% crossovers, and linkage means less than 50% crossovers. Hence a value greater than 50% cannot occur." It is evident that the conclusion of this curious syllogism depends solely on the definition of linkage contained in the second half of the second premise. It is true that crossover values significantly greater than fifty have never been found, but this is due to the frequency of double crossovers—to the fact that 'coincidence' is high for long distances. But coincidence is known to be a variable quantity, so that there would seem to be no *a priori* reason to suppose that crossover values greater than fifty are impossible. Furthermore, as has been explained above, map distances greater than 50 have never been intended to represent observed crossover values greater than fifty.

It is to be observed that the three dimensional figure given by Castle might seem capable of reduction to a curved line lying in one plane. An examination of his figure 2 shows that the only loci far from the plane that includes most of the group are bifid, depressed, shifted, lethal 3, furrowed, and lethal sc. Let us then examine these individually.

Bifid has already been shown to lie in the same straight line with yellow and white, both of which are in Castle's thickly populated plane.

Morgan and Bridges give three crossover values for depressed, two of which (white depressed and depressed vermilion) are stated to be based on 59

flies each. Such meager data are clearly insufficient to establish accurate crossover values. But the values given by Morgan and Bridges are themselves incorrect, as is shown by their account of the actual experiment (p. 68). The total number of flies is 69, not 59, and the crossover values accordingly become 17.4 for white depressed (instead of 20.3) and 14.5 for depressed vermilion (instead of 17.0). The sum of these values, 31.9, is not significantly different from 30.5, the accepted value for white vermilion. This relation, and the fact that the 69 flies included no double crossover, give no warrant for supposing that the locus of depressed is outside of the plane that includes white, vermilion, and bar.

Only two crossover values are given for shifted—shifted vermilion and shifted bar. It is evidently impossible to place a point in space by means of its distances from only two other points. Three are necessary, as Castle himself points out in connection with abnormal and bifid. There is thus no reason whatever for placing shifted out of the common plane.

The aberrant position of lethal 3 in Castle's model is evidently due in large part to the fact, shown by Morgan and Bridges (p. 75), that the experiments involving this locus gave a value of 2.3 for vermilion miniature, which is less than the mean value, 3.1, used by Castle. The values obtained in the lethal 3 experiments were:

Lethal 3 vermilion	6.8
Vermilion miniature	2.3
Lethal 3 miniature	9.3

The third value is substantially the same as the sum of the first two—hence the three loci must be represented as lying very nearly in a straight line.

In the case of furrowed, the values are all based on a few flies (240 or less in every case), and the three most important values (vermilion furrowed, miniature furrowed, and furrowed sable) were all obtained in different experiments, so that comparisons are hazardous. Furrowed is a character that is often difficult and sometimes impossible to classify, so that there is a large probability of error in the counts that have been reported.

In the case of lethal sc there is only one available crossover value (bar lethal sc, 8.3) small enough so that double crossing over would be negligible; and there are no data involving lethal sc and more than one other locus at the same time. The data are therefore not of the type to give a decisive answer as to the relations of the locus.

A careful examination of the data thus shows that a single plane suffices for the representation of the loci dealt with by Castle. Within this plane the positions of the remaining loci fall, in Castle's figure, roughly into a single curved line. The only noticeable exception is the locus of lemon. This locus is based on only 241 flies, and these gave rather too small a crossover value for the well established white vermilion distance, so that this discrepancy is not significant. The arrangement of the genes is thus approximately linear, but

the line is curved instead of straight. This curvature is due to the phenomenon of double crossing over, and the degree of curvature is dependent on the frequency of double crossovers; i.e., upon 'coincidence.' This method of representing coincidence, however, leads to inconsistencies. As was pointed out above, it is possible to build up the whole X-chromosome from successive overlapping sections, each of which is so short as to include few or no double crossovers. Yet double crossovers are not rare in longer sections. If ABC and BCD are sections so short that no double crossing over occurs within each, section ABCD may be long enough so that double crossing over in which one crossover is between A and B and the other between C and D may still occur; and in that case it becomes necessary to represent D in two positions at the same time. Such situations are actually known in Drosophila. Hence the curved line cannot give a consistent scheme; nor can any other scheme based on the assumption that long distances, as well as short ones, are to be represented as proportional to observed percentages of crossing over.

According to Castle the supposition that double crossovers do occur is "an unproved secondary hypothesis." Of course, if three genes are imagined as not lying in a straight line, a single plane may separate any one from the other two. Under these conditions double crossing over has no meaning. But the fact remains that when three linked genes are studied simultaneously, one pair of contrary classes is *always* small, and this class is always the one that is the double crossover class on the linear arrangement scheme. Some method of accounting for the smallness of this class is evidently demanded. Castle recognizes this, and suggests that the explanation may be either that "only transverse breaks occur, of which two taking place simultaneously are required to produce the difficult regrouping" (i.e., the familiar double crossover explanation), or that "transverse breaks are more frequent than oblique longitudinal ones, of which a single one would suffice to accomplish the regrouping, if the genes are not strictly linear in arrangement." Muller[4] has published data bearing on this point. He followed simultaneously eleven loci in the X-chromosome of Drosophila, and obtained some double crossover classes that according to Castle's model are impossible with a single plane. However, if the loci all reduce to the curved line discussed above, than any so-called double crossover is possible with a single separation plane. But those classes now termed triple and quadruple crossovers are all impossible with a single plane of crossing over. In the case of the X-chromosome over a dozen triple crossovers have been observed, and in the case of the second chromosome they are so frequent that 131 were observed in a single experiment. It follows that, even if the genes are not arranged in a straight line, the occurrence of double crossing over is an established fact, not an unproved hypothesis.

If crossover planes do not occur longitudinally, or occur thus less often than transversely, it is difficult to see how the distances apart of the loci in Castle's model can be proportional to the crossover values, except in the case where

the line joining the loci is perpendicular to the average direction of crossover planes. The crossover value for lines in any other directions would seem to be proportional to their *projections* on such a perpendicular. In short, both of Castle's alternative subsidiary hypotheses to account for the rarity of double crossovers are inconsistent with his primary assumption that distances are proportional to crossover values.

[1] These PROCEEDINGS, **5**, 1919, (25).

[2] Abnormal is a character that is separable from wild-type only under certain environmental conditions; and is also simulated by accidental abnormalities. It is, therefore, not a reliable character to use in linkage experiments.

[3] *Carnegie Inst., Washington, Pub.*, No. 237, 1916.

[4] Sturtevant, these PROCEEDINGS, **3**, 1917, (555), and Muller, *Amer. Naturalist*, 50, 1916, (193, 284, 350, 421).

[5] Bridges, *J. Exp. Zool.*, **19**, 1915, (1), and Plough; *Ibid.*, **24**, 1917, (147).

[6] Bridges and Sturtevant, *Bio'. Bull.*, **26**, 1914, (205), and Morgan and Bridges, loc. cit., note 3.

[7] That Castle tacitly recognized this is shown by the fact that he omitted lethal 2 from his model, without even mentioning the fact. It is obvious from an examination of the data in this case that the crossover values are inconsistent with those obtained in other experiments not involving lethal 2.

[8] Provided the relations of the loci are to be represented by straight lines joining them and proportional in length to the corresponding crossover values.

[9] It does not follow that 4.7 is to be taken as the locus of bifid, for the mean value indicated by all bifid experiments is the one most likely to coincide with future experiments; i.e., to give the best predictions.

[10] Castle concluded that the white forked value of 45.7, used by him, is somewhat too high, which is true; but there were available to him more than 40,000 flies (Bridges, *Genetics*, **1**, 1916, (1), and Weinstein, *Ibid.*, **3**, 1918, (135)) giving the lower value, in contrast to the less than 4000 flies on which the high value was based.

A COMPLETE APPARATUS FOR ABSOLUTE ACOUSTICAL MEASUREMENTS

BY ARTHUR GORDON WEBSTER

CLARK UNIVERSITY, WORCESTER, MASS.

Read before the Academy, November 17, 1915

The apparatus here briefly described is the result of researches begun many years ago in the attempt to solve the problem of measuring the intensity of sound at any given point of space in terms of absolute units, by means of instruments that may be reproduced from specifications, and that shall be convenient and portable. For this purpose three things are requisite; first, a source of sound that shall continuously produce a simple tone of known intensity—this will be denoted by the term 'phone;' second, an instrument for measuring in absolute units a constantly maintained simple tone, here called

a 'phonometer;' third, in order to check the theory of the two instruments a series of experiments on the propagation of sound from one to the other, free from the effect of disturbing bodies. Such experiments must be made either in a room so padded as to absorb all sound, which is at present impossible, or else out of doors at a distance from all objects except the flat surface of the earth, of which the coefficient of reflection is measured. This has been the method here pursued. While many observers have attacked one or both of the instrumental problems, it is not known that any has previously attacked all three parts above mentioned.

1. Phonometer.—In order to attain the required sensitiveness for the small amount of energy concerned, it is necessary to use the principle of resonance, and a coupled system of two degrees of freedom is used, the first consisting of a tunable air resonator, the second, of a tuned diaphragm which is to make the motion visible. Inasmuch as the sensitiveness will ultimately depend on the damping intrinsically residing in the diaphragm, it is desirable to reduce this as much as possible. For many years the best thing found was a glass diaphragm, tuned by adding weights. Finally it was found that mica diaphragms could be had having a smaller damping than glass. Finally, however, after an attempt to measure the loudness of some of the fog-signals on the Maine coast, all of which have different pitches, it was found necessary to have a diaphragm susceptible of gradual tuning, which could not be obtained by variation of mass. Accordingly the instrument was entirely redesigned, and the tuning was done by varying the potential, rather than the kinetic energy of the diaphragm, by stiffening it with a string tuned by tension. And now the chief improvement was made of abolishing the diaphragm, and since the resonator has a hole for the sound to enter, it was determined to replace the diaphragm by a rigid piston placed centrally in the hole, leaving an annular aperture for the sound to enter, and at the same time freeing us from the necessity of using the calculated equivalent area of the diaphragm. These improvements are embodied in the instrument shown in Figs. 1 and 2.

The phonometer is shown in elevation in Fig. 1, where 1 is the cylindrical resonator, sliding in the cylindrical piece screwed to the main casting A, resting on two feet and the cylinder 8. The end of the resonator is closed by a glass window 15. For years all measurements were made by the Michelson interferometer viewed stroboscopically, as it was desired to have the diaphragm absolutely free to move. For purposes of portability and convenience this has now been given up, and replaced by observing in a telescope the displacement of a mirror, as in Max Wien's phonometer. The interferometer, 14, (not shown) is attached temporarily at the front, or receiving end, to check the indications of the mirror. In the micrometer eyepiece, 2, adjustable with five degrees of freedom, is observed the image of the filament of the small lamp 4, fed through a key 5 by three dry cells, 10, placed in the cylindrical holder upon which the tube 7 is carried by a bayonet joint. The

vertical image of the filament is drawn out into a horizontal band. Details are shown in Fig. 2. The aluminium disk 12 is hung in the center of the hole in the front plate by means of the three steel wires clamped at one end by the spider 13, and at the other wound on the pins 8, turned by a key from the

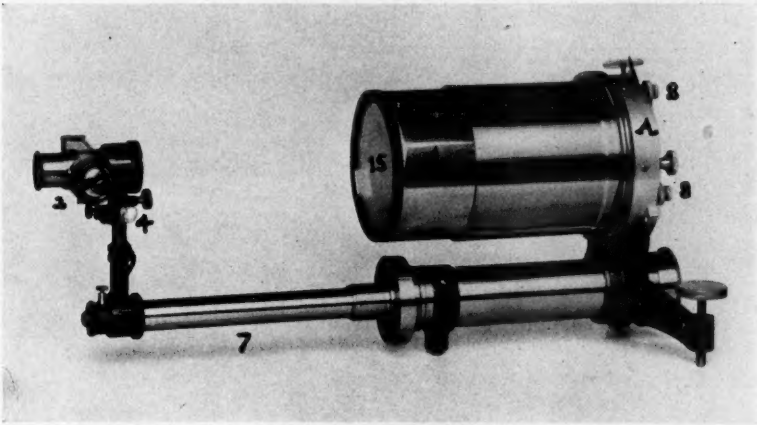
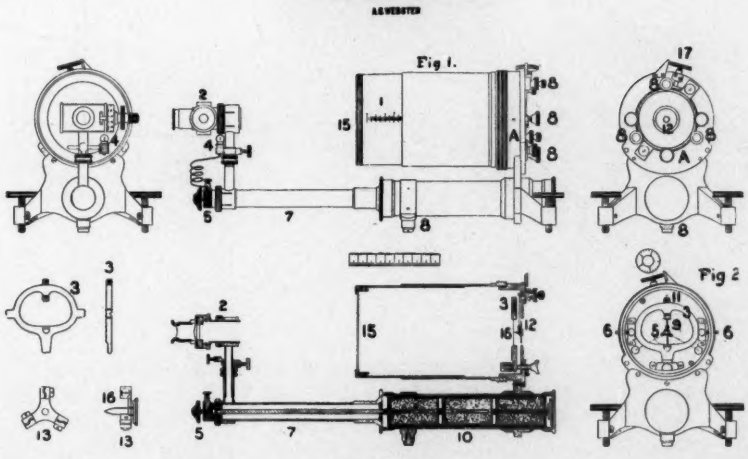


FIG. 1 A



FIGS. 1 and 2

outside, one controlled micrometrically by a lever and screw 17, by which the fine tuning is done. The wires pass over either one of two sets of three bridges cast on the front plate. The objective of the telescopic observing device is

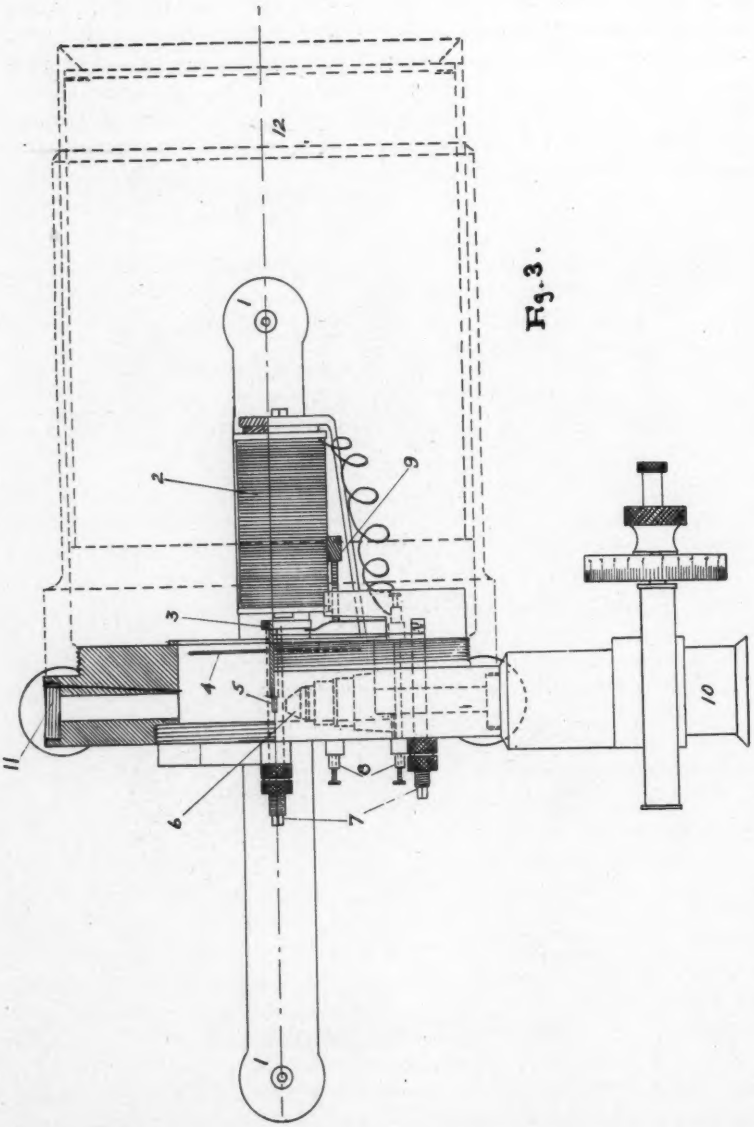


Fig. 3.

the small concave mirror 5, the back of which constitutes its own short lever, being directly pushed by a point 16 carried by the spider 13, which carries the disk 4. Instead of being pivoted in jewels, the mirror is carried by a torsion strip 9, cut from thin sheet steel with a square side projection upon which the mirror 5 is cemented. The strip is held by end clamps, and its tension may be adjusted by a screw 11, bearing on the spring 10, (inside). Two micrometric adjustments are secured by the strip being carried on a rocker 3, pivoted on two screws 6, allowing of sidewise displacement in order

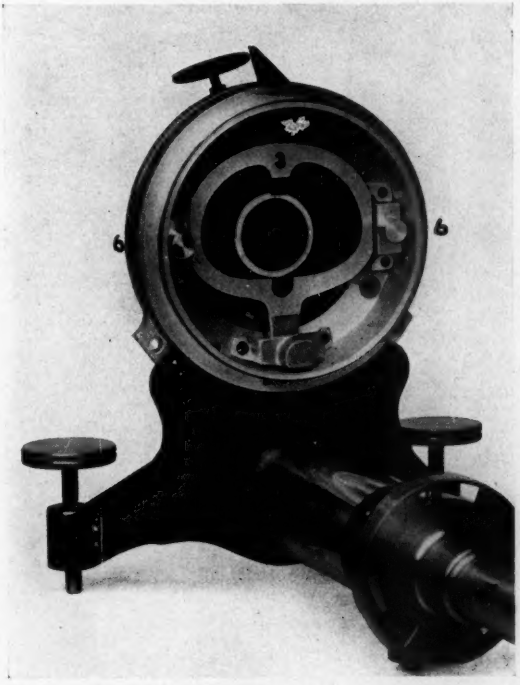


FIG. 2A

to change the lever arm of mirror 5, and thus the magnification of the motion. The motion of the image sidewise in the field of the ocular is obtained by a slow motion of the rocker, controlled by a screw at its lower end, accessible from outside. All other adjustments of the image are made at the ocular end. With the usual leverage of one-fourth to one-third of a millimeter between the point and the axis of the mirror, and a distance of forty centimeters to the reticule in the ocular, a magnification of about 2400 is obtained, and as one can read to one-tenth of a millimeter on the reticule, we may detect a dis-

placement of 1/24,000 millimeter of the vibrating disk, which is of the same order as could be used with the interferometer, and far better than could be done with a microscope. This phonometer is as sensitive as the normal ear (but for a very limited range).

2. Phone.–The phone, after having gone through many different forms, has now assumed a form closely connected with the phonometer, particularly as to the possibility of tuning. Fig. 3 shows the form now chiefly used. The disk 3, placed centrally in the hole of the resonator, supported in its wires and tuning pins 7, is actuated by an electromagnet 9, the current of which is inter-

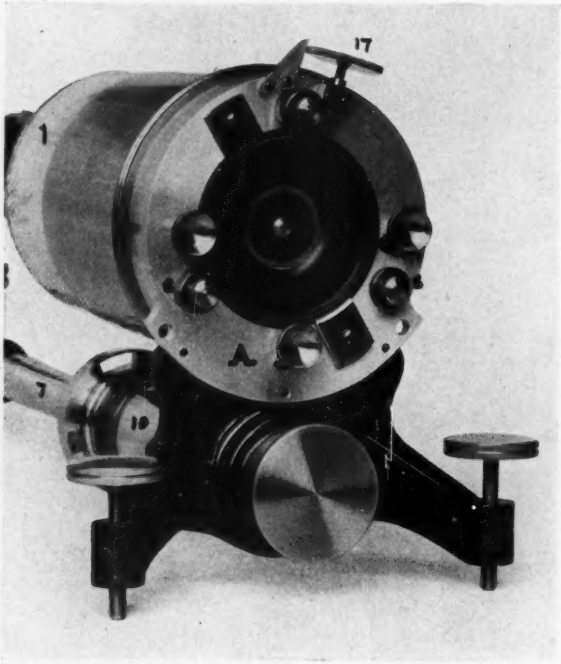


FIG. 2B

rupted by a separate electrically-maintained tuning-fork with a platinum point dipping into mercury. If exact purity of sound is not important, and the slight fizzing always associated with a dry contact is unobjectionable, a spring interrupter may be used, and the phone is self-contained, but generally it is better to have a set of forks to be used in the interchangeable stand, to control the phone at various pitches.

During the last year I have made the acquaintance of the pliotron and found it to be a wonderfully convenient instrument for the production of

harmonically varying currents. I accordingly adopted it instead of the interrupting tuning fork, inasmuch as it could be instantaneously tuned to any pitch whatever, and we are therefore freed from the necessity of being confined to four or five pitches, but have perfectly continuous range. The intensity of the sound emitted is measured by the amplitude of vibration of the disk, read off by the micrometer 10, focused on a fine slit ruled in the silvering of a piece of cover-glass 5 carried by the disk, and illuminated by an incandescent lamp and condenser not shown. It may be remarked that this phone as it stands may be used as a phonometer for tolerably loud sounds, such as those of singing near by, which gives a considerable vibration in the microscope. It should be likewise stated that this phone produces sound more efficiently than any other known instrument.

The *theory* of the phonometer and the phone is given in another paper.

NATIONAL RESEARCH COUNCIL

EXTRACT OF MINUTES OF JOINT MEETINGS OF THE EXECUTIVE BOARD OF THE NATIONAL RESEARCH COUNCIL WITH THE COUNCIL OF THE NATIONAL ACADEMY OF SCIENCES

AT THE NATIONAL RESEARCH COUNCIL BUILDING

MEETING OF JANUARY 14, 1919, AT 10 A.M.

Present: Messrs. Abbot,* Bogert, Clevenger, Cross,* Hale,* Howe, Howell,* Hussey, Johnston, Mendenhall, Michelson,* Millikan, Noyes,* Russell, Walcott,* Welch, Woods, Yerkes, and by invitation, Leuschner and Nichols.

Mr. Hale presided during the first part of the meeting while the business of the National Research Council was under consideration.

The minutes of the meetings of the Executive Board, December 21, 1918, and of the Interim Committee, December 31, 1918, and January 6–7, 1919, were approved as circulated.

Mr. Hale presented a report of the Committee on the Patent Office, appointed December 4, 1917, L. H. Baekeland, Acting Chairman. The report was duly considered and approved and it was

Moved: That the necessary funds be set aside for printing the report of the Committee on the Patent Office in full. (*Adopted.*)

The Chairman presented the resignation of Mr. S. L. G. Knox as Scientific Attaché to the Embassy in Rome, in charge of the Research Information Service in Italy and it was

Moved: That the resignation of Mr. S. L. G. Knox be accepted and that the National Research Council express its appreciation of the important services which he has rendered to the Council and convey to him a vote of thanks. (*Adopted.*)

Moved: That the Committee on Relations with Educational Institutions be increased to include as members Mr. S. P. Capen of the Bureau of Education, Mr. R. M. Yerkes, Mr. A. O. Leuschner, and Mr. H. E. Gregory. (*Adopted.*)

The Chairman called upon Mr. Leuschner to state the situation as to the Smith-Howard Bill for the promotion of research in connection with educational institutions, which is now under consideration by Congress. After discussion it was

Moved: That a Committee of seven with full power to act be appointed by the Chairman to consider the whole question of a Bill in Congress to provide appropriations for research, and that the President of the National Academy of Sciences and the Chairman of the National Research Council be members of the Committee. (*Adopted.*)

---

*Members of the Council of the National Academy of Sciences.

At this point Mr. Walcott took the chair and Mr. Hale presented a draft of a proposed Constitution of the National Research Council. After discussion of this draft it was

Moved: That the draft o the Constitution be referred back to the Committee with the request that it report at the next meeting, and that copies of the draft of the Constitution as revised be circulated among the members of the Council of the National Academy of Sciences and of the Executive Board of the National Research Council, prior to the meeting when its adoption is to be considered. (*Adopted.*)

The meeting adjourned at 1.00 pm.

PAUL BROCKETT, *Assistant Secretary.*

MEETING OF FEBRUARY 11, 1919, AT 9.30 A.M.

Present: Messrs. Clevenger, Cross,* Hale,* Howe, Hussey, Johnston, Manning, Millikan, Noyes,* Pupin,* Stratton, Walcott,* Welch, Woods, Woodward, and by invitation, Leuschner. Mr. Hale in the chair.

The minutes of the meeting of the Council of the National Academy of Sciences, on December 30, 1918, and of the joint meeting of the Executive Board of the National Research Council and the Council of the National Academy of Sciences, on January 14, 1919, were approved, as were the minutes of the several meetings of the Interim Committee, on January 21, 30, and February 5, 1919, except that two motions of February 5 relative to publication were amended to read as follows:

That the publication of a series of bulletins on the general activities of the National Research Council be authorized, and that the matter be left to the Chairman and Secretary with power.

That accounts of scientific work done under the auspices of the National Research Council shall in general be published in scientific periodicals, provided that the connection of the Council with the work is acknowledged in a footnote or otherwise; and that the Council procure, and pay the cost of, a sufficient number of reprints of such articles.

The Chairman presented a revised plan of Organization of the National Research Council which was discussed in detail.

Moved: That the Executive Board of the National Research Council approve and recommend to the Council of the National Academy of Sciences the adoption of the Organization of the National Research Council as presented. (*Adopted.*)

The organization as finally adopted is given on page 184.

The Council of the National Academy of Sciences and the Executive Board of the National Research Council adjourned at 1.08 p. m.

*Members of the Council of the National Academy of Sciences.

The Council of the National Academy of Sciences resumed session at 1.09 p.m., Mr. Walcott in the chair.

The President presented the Organization of the National Research Council recommended by the Executive Board for adoption by the Council of the National Academy.

Moved: That the organization as submitted and approved by the Executive Board be approved by the Council of the National Academy of Sciences. (*Adopted.*)

The meeting then adjourned.

The Council of the National Academy of Sciences and the Executive Board of the National Research Council reassembled in joint session at 2.45 p.m.

Present: Messrs. Clevenger, Cross,* Hale,* Howe, Hussey, Johnston, Millikan, Noyes,* Pupin,* Walcott,* Woods, and by invitation, Leuschner. Mr. Noyes in the chair.

The Chairman of the National Research Council presented the following communication from Mr. Theodore N. Vail, President of the American Telephone and Telegraph Company:

The Bell Telephone System, composed of the American Telephone and Telegraph Company, its associated and operating, and the Western Electric companies acting through the American Telephone and Telegraph Company, guarantees to the National Research Council $25,000 a year if not less than $250,000 a year for five years be raised for the use of the Council.

The Bell Telephone System to have the benefit of the advice, assistance and coöperation of the Council in all matters relating to its industry.

Moved: That all matters relating to publication and publicity be referred to, and carried on under, the Research Information Service. (*Adopted.*)

Moved: That the scale of annual salaries of the National Research Council be as follows: Chairman of the National Research Council, $10,000; Chairmen of Divisions of Science and Technology, $6000, with an additional allowance of $1000 for traveling expenses if they are sent abroad by the Council; Scientific Attachés, $6000, until the Council is in a position to pay more. (*Adopted.*)

Moved: That Mr. J. C. Merriam be elected Acting Chairman of the National Research Council from March 15 until a new Chairman takes office. (*Adopted.*)

Moved: That Major R. M. Yerkes be elected Chairman of the Research Information Service. (*Adopted.*)

Moved: That the resignation of Mr. Graham Edgar as Secretary of the Washington office of the Research Information Service be accepted with regret; and that the Council express to him its appreciation of his work. (*Adopted.*)

Moved: That Mr. G. S. Fulcher be elected as Secretary of the Washington office of the Research Information Service, his appointment to date from February 1, 1919. (*Adopted.*)

The resignation of Mr. Yerkes as Chairman of the Psychology Committee was received and accepted with the understanding that it is to go into effect at the time of the organization of the Division of Anthropology and Psychology.

* Members of the Council of the National Academy of Sciences.

Moved: That the Council express its appreciation of the very valuable work which Mr. Yerkes has done as Chairman of the Psychology Committee and in connection with the organization of the Division of Psychology of the Surgeon General's Office, and convey its thanks to him. (*Adopted.*)

Moved: That the resignation of Mr. H. A. Bumstead as Scientific Attaché to the American Embassy in London, in charge of the Research Information Service in Britain, be accepted with regret; and that the National Research Council express appreciation of the admirable work which he has done and convey its thanks to him. (*Adopted*).

Moved: That Mr. C. E. Mendenhall be elected to take the place of Mr. Bumstead as Scientific Attaché to the American Embassy in London. (*Adopted.*)

Moved: That the resignation of Rear-Admiral Roger Welles from the Research Information Service be accepted and that an expression of thanks be extended to him for the able service which he has rendered the National Research Council. (*Adopted.*)

Moved: That the Executive Board request the President of the National Academy to ask the President of the United States to designate Captain George W. Williams to take the place of Admiral Welles on the Research Information Service. (*Adopted.*)

Moved: That a vote of thanks be extended to Major-General W. C. Gorgas, Surgeon General U. S. A., for the valuable service which he has rendered to the National Research Council. (*Adopted*).

Moved: That the President of the National Academy of Science be requested to ask the President of the United States to designate Surgeon General M. W. Ireland to take the place of General Gorgas on the Research Council. (*Adopted.*)

On recommendation of Secretary Johnston of the National Research Council it was

Moved: That the following allotments be authorized from the appropriation from the President's emergency fund of $61,000 available for expenses of the Council from January 1 to June 30, 1919: General and Office Administration, $33,000; Research Information Service, $20,000. (*Adopted.*)

The Chairman of the Engineering Division *moved:* That Mr. Clevenger be elected Vice Chairman of the present Division. (*Adopted.*)

The Chairman of the Engineering Division *moved:* That the organization of a Manganese Saving Committee be authorized, with Mr. J. R. Cain as Chairman; and that an allotment of $150 from the funds available for the Engineering Division be placed at the disposal of this Committee. (*Adopted.*)

The Vice-chairman of the Division of Medical Sciences made the following statements concerning grants recommended by the Executive Committee of the Division:

Dr. C. A. Kofoid, representing the section on Protozoology of the Medical Zoology Committee of this Division has been engaged in examining troops at Hoboken returning from France, studying the flora of human intestinal protozoa. This work has been interfered with on account of the changes in the status of personnel due to demobilization. It is important that this work should be continued for two essential reasons: such an opportunity for so complete a study will hardly present itself again in the near future, and we have no treatise at present which deals with any comprehensive, extensive study of the flora of parasites in the human intestines; also the results of this work will determine whether our troops acquired foreign parasites. A sufficient number of men who did not go to France are being examined for control. To continue this work it is necessary to have a permanent assistant. Dr. Kofoid has requested that we appropriate funds sufficient to pay the salary of such an

assistant, and further requests that Dr. Olive Swazey of the Department of Zoology at the University of California be appointed at a salary of $2100 per annum and traveling expenses from the University of California to Hoboken. The Executive Committee of the Medical Division recommends this appropriation for one year.

A grant of $500 has been approved to support investigations on measles now in progress at Camp Devens conducted by Dr. Sellards. This amount is to be paid to Colonel F. F. Russell to be expended at his discretion.

Moved: That the above recommendations of the Division of Medical Sciences be approved. (*Adopted.*)

Mr. Hale *moved:* That the President of the American Association for the Advancement of Science, or a representative of the Association, be made ex-officio a member of the Executive Board. (*Adopted.*)

Moved: That the Executive Board of the National Research Council recommend to the Council of the National Academy of Sciences that authority be given for the inclusion of the following as a Section in the Plan of Organization of the National Research Council.

ARTICLE VIII—AMENDMENT OF THE ORGANIZATION

Section 1. This organization may be amended by a two-thirds vote of the Council of the National Academy of Sciences at any stated meeting, provided that notice of the proposed amendment has been given to each member of the Council of the National Academy at least thirty days in advance of the stated meeting. (*Adopted.*)

The meeting adjourned at 4 p.m.

PAUL BRACKETT, *Assistant Secretary.*

ORGANIZATION OF THE NATIONAL RESEARCH COUNCIL

PREAMBLE

The National Academy of Sciences, under the authority conferred upon it by its charter enacted by Congress, and approved by President Lincoln on March 3, 1863, and pursuant to the request expressed in an Executive Order made by President Wilson on May 11, 1918, hereto appended, adopts the following permanent organization for the National Research Council, to replace the temporary organization under which it has operated heretofore.

ARTICLE I. PURPOSE

It shall be the purpose of the National Research Council to promote research in the mathematical, physical, and biological sciences, and in the application of these sciences to engineering, agriculture, medicine, and other useful arts, with the object of increasing knowledge, of strengthening the national defense, and of contributing in other ways to the public welfare, as expressed in the Executive Order of May 11, 1918.

ARTICLE II. MEMBERSHIP

Section 1. The membership of the National Research Council shall be chosen with the view of rendering the Council an effective federation of the principal research agencies in the United States concerned with the fields of science and technology named in Article I.

Section 2. The Council shall consist of

1. Representatives of national scientific and technical societies;
2. Representatives of the Government, as provided in the Executive Order;
3. Representatives of other research organizations and other persons whose aid may advance the objects of the Council.

ARTICLE III. DIVISIONS

Section 1. The Council shall be organized in Divisions of two classes:

A. Divisions dealing with the more general relations and activities of the Council;

B. Divisions dealing with related branches of science ond technology.

Section 2. The initial constitution of the Divisions of the Council shall be as follows:

A. Divisions of General Relations

I. Government Division,
II. Foreign Relations Division,
III. States Relations Division,
IV. Educational Relations Division,
V. Industrial Relations Division,
VI. Research Information Service,

B. Divisions of Science and Technology

VII. Division of Physical Sciences,
VIII. Division of Engineering,
IX. Division of Chemistry and Chemical Technology,
X. Division of Geology and Geography,
XI. Division of Medical Sciences,
XII. Division of Biology and Agriculture,
XIII. Division of Anthropology and Psychology.

Section 3. The number of divisions and the grouping of subjects in Article III, Section 2, may be modified by the Executive Board of the National Research Council.

Section 4. The Divisions of General Relations shall be organized by the Executive Board of the National Research Council (Article IV, Section 2).

Section 5. To secure the effective federation of the principal research agencies in the United States, provided for in Article II, a majority of the members of each Division in the group of Science and Technology shall consist of representatives of scientific and technical societies, chosen as provided for in Article V, Section 2. The other members of the Division shall be nominated by the Executive Committee of the Division, approved by the Executive Board of the National Research Council, and appointed in accordance with Article V, Section 4.

Section 6. The Divisions of the Council, with the approval of the Executive Board, may establish sections and committees, any of which may include members chosen outside the membership of the Council.

ARTICLE IV. ADMINISTRATION

Section 1. The affairs of each Division shall be administered by a Chairman, a Vice-Chairman, and an Executive Committee, of which the Chairman and the Vice-Chairman shall be ex-officio members, all of whom shall be elected annually by the Division and confirmed by the Executive Board.

Section 2. The affairs of the National Research Council shall be administered by an Executive Board, of which the President and Home Secretary of the National Academy of Sciences, the President of the American Association for the Advancement of Science, the chairmen and vice-chairmen of the Divisions of Science and Technology, and the chairmen of the Divisions of General Relations shall be ex-officio members. The Executive Board may elect additional members, not to exceed ten in number, who, if not already members of the National Research Council, shall be appointed thereto, in accordance with Article V, Section 4.

Section 3. The officers of the National Research Council shall consist of a Chairman, one or more Vice-Chairmen, a Secretary, and a Treasurer, who shall also serve as members and officers of the Executive Board of the Council.

Section 4. The officers of the National Research Council, excepting the Treasurer, shall be elected annually by the Executive Board. The Treasurer of the National Academy of Sciences shall be ex-officio Treasurer of the National Research Council.

Section 5. The duties of the officers of the Council and of the Divisions shall be fixed by the Executive Board.

ARTICLE V. NOMINATIONS AND APPOINTMENTS

Section 1. The government bureaus, civil and military, to be represented in the Government Division, and the scientific and technical societies, to be represented in the Divisions of Science and Technology of the National Research Council, shall be determined by joint action of the Council of the National Academy of Sciences and the Executive Board of the National Research Council.

Section 2. Representatives of scientific and technical societies shall be nominated by the societies, at the request of the Executive Board, and appointed by the President of the National Academy of Sciences to membership in the Council and assigned to one of its divisions.

Section 3. The representatives of the government shall be nominated by the President of the National Academy of Sciences after conference with the Secretaries of the Departments concerned, and the names of those nominated shall be presented to the President of the United States for designation by him for service with the National Research Council.

Section 4. Other members of the Council shall be nominated by the Executive Committees of the Divisions, approved by the Executive Board, and appointed by the President of the National Academy of Sciences to membership and assigned to one of the Divisions.

Section 5. Prior to the first annual meeting of the Council following January 1, 1919, all Divisions shall be organized by appointment of their members in accordance with Article II and Article V, Sections 1 to 4.

Section 6. As far as practicable one-third of the original representatives of each scientific and technical society and approximately one-third of the other

original members of each of the Divisions of Science and Technology shall serve for a term of three years, one-third for a term of two years, and one-third for a term of one year, their respective terms to be determined by lot. Each year thereafter, as the terms of members expire, their successors shall be appointed for a period of three years.

Section 7. The government representatives shall serve for periods of three years, unless they previously retire from the government office which they represent, in which case their successors shall be appointed for the unexpired term.

Section 8. As far as practicable a similar rotation shall be observed in the appointment of the members of the Divisions of General Relation.

ARTICLE VI. MEETINGS

Section 1. The Council shall hold one stated meeting, called the annual meeting, in April of each year, in the city of Washington, on a date to be fixed by the Executive Board. Other meetings of the Council shall be held on call of the Executive Board.

Section 2. The Executive Board and each of the Divisions shall hold an annual meeting, at which officers shall be elected, at the time and place of the annual meeting of the Council, unless otherwise determined by the Executive Board, and such other meetings as may be required for the transaction of business.

Section 3. Joint meetings of the Executive Board of the National Research Council and the Council of the National Academy of Sciences shall be held from time to time, to consider special requests from the government, the selection of organizations to be represented in the National Research Council, and other matters which, in the judgment of the President of the National Academy, requires the attention of both bodies.

ARTICLE VII. PUBLICATIONS AND REPORTS

Section 1. An annual report on the work of the National Research Council shall be presented by the chairman to the National Academy of Sciences, for submission to Congress in connection with the annual report of the President of the Academy.

Section 2. Other publications of the National Research Council may include papers, bulletins, reports, and memoirs, which may appear in the Proceedings or Memoirs of the National Academy of Sciences, in the publications of other societies, in scientific and technical journals, or in a separate series of the Research Council.

EXECUTIVE ORDER ISSUED BY THE PRESIDENT OF THE UNITED STATES, MAY 11, 1918

The National Research Council was organized in 1916 at the request of the President by the National Academy of Sciences, under its Congressional charter, as a measure of national preparedness. The work accomplished by the Council in organizing research and in securing co-operation of military and civilian agencies in the solution of military problems demonstrates its capacity for larger service. The National Academy of Sciences is therefore requested to perpetuate the National Research Council, the duties of which shall be as follows:

1. In general, to stimulate research in the mathematical, physical and biological sciences, and in the application of these sciences to engineering, agriculture, medicine, and other useful arts, with the object of increasing knowledge, of strengthening the national defense, and of contributing in other ways to the public welfare.

2. To survey the larger possibilities of science, to formulate comprehensive projects of research, and to develop effective means of utilizing the scientific and technical resources of the country for dealing with these projects.

3. To promote co-operation in research, at home and abroad, in order to secure concentration of effort, minimize duplication, and stimulate progress; but in all co-operative undertakings to give encouragement to individual initiative, as fundamentally important to the advancement of science.

4. To serve as a means of bringing American and foreign investigators into active co-operation with the scientific and technical services of the War and Navy Departments and with those of the civil branches of the Government.

5. To direct the attention of scientific and technical investigators to the present importance of military and industrial problems in connection with the war, and to aid in the solution of these problems by organizing specific researches.

6. To gather and collate scientific and technical information at home and abroad, in co-operation with Governmental and other agencies and to render such information available to duly accredited persons.

Effective prosecution of the Council's work requires the cordial collaboration of the scientific and technical branches of the Government, both military and civil. To this end representatives of the Government, upon the nomination of the President of the National Academy of Sciences, will be designated by the President as members of the Council, as heretofore, and the heads of the departments immediately concerned will continue to co-operate in every way that may be required.

WOODROW WILSON.

The White House,
May 11, 1918.

MINUTES OF JOINT MEETING OF THE EXECUTIVE BOARD AND THE COUNCIL OF THE NATIONAL ACADEMY OF SCIENCES

AT THE NATIONAL RESEARCH COUNCIL BUILDING

MARCH 11, 1919, AT 9.45 A.M.

Present: Messrs. Abbot,* Bogert, Bumstead, Clevenger, Cross,* Hale,* Howe, Hussey, Johnston, Leuschner, Manning, Michelson,* Millikan, Noyes,* Pupin,* Walcott,* Washburn, Woods, Yerkes.

Minutes of the joint meeting of February 11, as circulated by mail, were approved.

Mr. Hale presented a cablegram from Dr. Schuster, Secretary of the Royal Society, in regard to the admission of neutral nations to the International Research Council.

Moved: That the Council of the National Academy of Sciences and the Executive Board of the National Research Council recommend to the International Research Council that, on the conclusion of peace, nations with sufficient scientific development, which have been neutral during the war, be invited to join the International Research Council. (*Adopted.*)

Moved: That the foregoing resolution be submitted to the National Academy of Sciences for approval. (*Adopted.*)

It was the sense of the joint meeting that the International Research Council should be requested to take action at an early date in the matter of inviting such neutrals to join the Council.

Upon motion of Mr. Hale, acting upon the suggestion of Mr. Elihu Root, Resolved: The Council of the National Academy of Sciences recommends to the Academy the addition of the following paragraph to Section 2, Article II, of the Constitution of the Academy: "It shall be competent for the Council to call in experts or men of special attainments not members of the Academy, to aid, under special permanent organizations, in promoting the objects of the Academy."

Mr. Hale, member for the United States of the Executive Committee of the International Research Council, reported that in accordance with a resolution passed at the November meeting of the International Research Council in Paris, a tentative plan for the formation of an American Section of the proposed International Astronomical Union had been adopted with the approval of the President of the National Academy of Sciences and that the Section had organized under the tentative plan at a meeting held in Washington. The tentative organization provides that the initial membership shall include representatives of organizations as follows:

National Academy of Sciences	5
American Astronomical Society	10
American Physical Society	5

* Members of the Council of the National Academy of Sciences.

American Mathematical Society	3
U. S. Naval Observatory	1
U. S. Nautical Almanac Office	1
U. S. Coast and Geodetic Survey	1

Messrs. Hale and Leuschner then presented the minutes of the organization meeting of the Section, as printed on page 193.

Moved: That the Council of the National Academy of Sciences and the Executive Board of the National Research Council approve the provisional organization of the American Section of the International Astronomical Union. (*Adopted.*)

Mr. Leuschner then presented the following recommendation of the Division of Physical Sciences:

Moved: That in accordance with its offer to serve as the agency in Astronomy of the Council, the American Section of the International Astronomical Union be constituted a Section on Astronomy of the Division of Physical Sciences. (*Adopted.*)

Mr. Leuschner reported that in harmony with a further resolution of the International Research Council, a committee consisting of Messrs. R. S. Woodward, L. A. Bauer, William Bowie, A. O. Leuschner, Whitman Cross, and C. F. Marvin, had been appointed to consider the question of the tentative organization of an American Section of the proposed International Geophysical Union, and that a report submitted by this committee to the Chairman of the Council had been carefully considered by the Executive Committee of the Division of Physical Sciences which had voted to submit the following recommendations:

That the tentative formation of an American Section of the proposed International Geophysical Union be approved, with the provision that the subjects to be included and their grouping be determined by the Section after its organization.

That the question of the formation of an American Geophysical Society be referred to the Section.

Mr. Leuschner then presented the following provisional nominations on behalf of the Executive Committee of the Division of Physical Sciences for membership in the Section:

Messrs. S. J. Barnett, Joseph Barrell, L. A. Bauer, H. B. Bigelow, W. R. Blair, E. H. Bowie, William Bowie, J. C. Branner, E. W. Brown, Whitman Cross, R. A. Daly, A. L. Day, J. F. Hayford, W. J. Humphreys, A. O. Leuschner, G. W. Littlehales, G. F. MacEwen, C. F. Marvin, Max Mason, A. G. McAdie, A. A. Michelson, R. A. Millikan, F. R. Moulton, H. F. Reid, Frank Schlesinger, R. B. Sosman, J. T. Watkins, H. O. Wood, R. S. Woodward.

Moved: That these recommendations and provisional nominations of the Division of Physical Sciences be approved. (*Adopted.*)

Mr. Hale brought to the attention of the meeting the question of a popular journal to be published jointly by the National Academy of Sciences and the American Association for the Advancement of Science, and stated that the matter would be brought up later for further consideration.

Mr. Yerkes brought up for consideration the question of securing funds for the preparation of a suitable scale for the mental rating of school children, and stated that the General Education Board was prepared to make an appropriation of $25,000 to meet the expenses of the work if requested to do so by the National Research Council. On motion, the Chairman of the Council was authorized to make such application to the General Education Board.

Mr. Noyes *moved:* That the Executive Board approve the undertaking by the Council of a project of which the broad purpose is to promote fundamental research in physics and chemistry in educational institutions—the project to consist primarily in the organization and maintenance of a system of National Research Fellowships to be awarded to persons who have already demonstrated a high order of ability in research, for the purpose of enabling them to carry on investigations at educational institutions making adequate provision for the prosecution of research in physics and chemistry. (*Adopted.*)

The constitution of a Board to formulate and administer this project was approved, with the proviso that if any member cannot give active service to the work his name shall be withdrawn and another substituted. It was also agreed that Mr. Hale be asked to act temporarily as Chairman.

Mr. Hale proposed that the Division of Foreign Relations include a representative each of the State Department, the National Academy of Sciences, the American Association for the Advancement of Science, the American Philosophical Society, the American Academy of Arts and Sciences; Honorable Elihu Root, former Secretary of State; the Chairmen of the National Research Council and of the Research Information Service; together with one representative each of leading international scientific and technical organizations in which the United States takes part, such as the International Surgical Association, American Section of the International Astronomical Union, the American Section of the International Geophysical Union, International Bureau of Weights and Measures, etc.

Moved: That the foregoing plan of organization be approved, that the Chairman of the National Research Council be authorized to proceed with its completion; and that the Foreign Secretary of the National Academy be the Chairman of the Division of Foreign Relations. (*Adopted.*)

Mr. Howe *moved:* That all committees of the various Divisions serve until the annual meeting and that the list of committees and their membership be revised each year at the annual meeting of the Executive Board, in accordance with recommendations to be submitted by the Divisions. (*Adopted.*)

Moved: That the questions of this year's annual meeting, of the National Research Council, of the beginning of the financial year, and of the date of appointment of members, be referred to the Interim Committee, with power to act. (*Adopted.*)

Moved: That consideration of the following amendment to the Organization of the National Research Council be postponed until the next stated meeting of the Council of the National Academy of Sciences:

ARTICLE VIII—AMENDMENT OF THE ORGANIZATION

Section 1. This organization may be amended by a vote of the Council of the National Academy of Sciences at any stated meeting, provided that notice of the proposed amendment has been given to each member of the Council of the National Academy at least thirty days in advance of the stated meeting. (*Adopted.*)

Moved: That the Budget Committee be directed to confer with the Finance Committee of the National Academy of Sciences and with Mr. Gano Dunn concerning a plan for the administration of the financial affairs of the National Research Council under the provision of the new organization by which "the Treasurer of the National Academy of Sciences shall be ex-officio Treasurer of the National Research Council" and to submit such a plan with recommendations. (*Adopted.*)

In accordance with the resolution, passed at a previous meeting, that the Budget Committee make recommendations for allotments to the several Divisions on the basis of their minimum requirements for the period ending June 30, 1919, the Budget Committee presented the following resolutions:

That the balances of allotments to the several Divisions, amounting in all to $45,378.99 be and are hereby reverted to the unappropriated fund.

That appropriations to the several Divisions amounting in all to $39,200, be made for the period February 1 to June 30, 1919.

On this basis the unappropriated funds of the Council derived from the Carnegie Foundation are $50,810.01; the unappropriated fund available from the Government is $8,000.

Moved: That the foregoing recommendations of the Budget Committee be approved. (*Approved.*)

The Chairman presented a check from Dr. W. W. Keen of Philadelphia, amounting to $106.22, being the proceeds from the recent sales of the book which he prepared for the National Research Council entitled "Treatment of War Wounds."

Moved: That a vote of thanks and appreciation be extended to Dr. Keen for this further gift to the funds available for research in connection with the Division of Medicine and Related Sciences. (*Adopted.*)

Moved: That the new Divisions be considered to be effective when the divisional nominations have been approved by the Executive Board, and that present officers of Divisions shall continue to serve until their successors shall have been elected. (*Adopted.*)

Mr. Hale reported on the present status of the organization of the Divisions and presented the nominations received to date for membership on the Divisions of Physical Sciences, Chemistry and Chemical Technology, and Engineering.

Moved: That the nominations as presented be approved, and that the approval of the nominations required to complete the foregoing Divisions be referred to the Interim Committee with power. (*Adopted.*)

Moved: That the question of the publication of the following bulletins be referred to the Interim Committee, with power:

1. National Importance of Scientific and Industrial Research (Hale and others)
2. Report of Committee on Patent Office (Baekeland)
3. Report of the Psychology Committee of the National Research Council (Yerkes)

4. Some Problems of Sidereal Astronomy (Russell)
5. Refractories (Washburn)
6. Industrial Research (Jewett)
7. Scientific Abstracts (Fulcher)

Moved: That Mr. C. P. Townsend be elected a member of the Patent Office Committee. (*Adopted.*)

Moved: That Mr. James R. MacColl be elected a member of the Advisory Committee of the Industrial Research Section. (*Adopted.*)

Moved: That the resignation of Mr. W. F. Durand as Scientific Attaché to the American Embassy at Paris, in charge of the Research Information Service in France, be accepted with regret and that the National Research Council express appreciation of the admirable work which he has done and convey its thanks to him. (*Adopted.*)

Moved: That the resignation of Mr. Edgar Buckingham as Associate Scientific Attaché at Rome, and technical assistant with the Research Information Service in Italy, be accepted with regret and that a vote of thanks be extended to him for the work which he has rendered in this service. (*Adopted.*)

Moved: That the resignation of Mr. Charles E. Mendenhall as Vice-Chairman of the Division of Physics, Mathematics, Astronomy and Geophysics be accepted with regret; and that the Council express to him its appreciation of the valuable services which he has rendered. (*Adopted.*)

Moved: That Mr. A. O. Leuschner be elected Acting Chairman of the Division of Physics, Mathematics, Astronomy and Geophysics. (*Adopted.*)

Moved: That the resignation of Mr. John Johnston be accepted with regret and that the Chairman be requested to express to him the great appreciation of the work which he has done for the National Research Council, and that the acceptance of this resignation be effective when his successor is appointed. (*Adopted.*)

Moved: That the transportation expenses of the members of the Division of Chemistry and Chemical Technology attending the first meeting of the Division, to be held in Washington March 21 and 22, be met by the Council, as a means of assuring a full attendance at this initial meeting; and that the Interim Committee be authorized to make arrangements for the payment of expenses of members attending the initial meetings of other Divisions. (*Adopted.*)

Upon the request of Mr. Merriam the Chairman presented the following resolution:

Moved: That the sum of $500 be set aside for general maintenance of the Division of Educational Relations from the present date to June 30, 1919. (*Adopted.*)

The Treasurer, Mr. Cross, presented the financial statement for the month ending February 28, 1919, which was accepted.

The meeting adjourned at 1 p.m.

PAUL BROCKETT, *Assistant Secretary.*

ORGANIZATION MEETING OF THE AMERICAN SECTION OF THE PROPOSED INTERNATIONAL ASTRONOMICAL UNION

At the organizing meeting of the International Research Council held in Paris in November 1918, it was decided to establish an International Astronomical Union, to continue and extend the work formerly conducted by such international astronomical organizations as the committee of the Carte du Ciel, the International Union for Co-operation in Solar Research, and similar bodies

less formally constituted which dealt with various questions relating to astronomy and its applications. The International Research Council adopted a resolution requesting the National Academy of Sciences, or the corresponding organization in each of the countries represented, to take the initiative in organizing the section to represent that country in the International Astronomical Union. The tentative plan of organization of the American Section of the Astronomical Union, as approved by the President of the National Academy of Sciences, involved the representation of the various interests concerned as given below.

Upon the call of Dr. George E. Hale, acting for the National Academy of Sciences, the organization meeting for the American Section of the proposed Astronomical Union was held in the office of the National Research Council, Washington, D. C., March 8, 1919. The delegates who had been appointed by the presidents of the respective societies, or by the government, were as follows:

National Academy of Sciences, 5.—H. D. Curtis acting for W. W. Campbell, G. E. Hale, A. A. Michelson, F. R. Moulton, Frank Schlesinger.

American Astronomical Society, 10.—C. G. Abbot, S. I. Bailey, E. W. Brown, E. B. Frost, A. O. Leuschner, S. A. Mitchell, W. J. Humphreys, H. N. Russell, Joel Stebbins, (absent, J. F. Hayford).

American Mathematical Society, 3.—Frank Morley, (others to be appointed).*

American Physical Society, 3.—Henry Crew, (absent, J. S. Ames, Theodore Lyman).

U. S. Naval Observatory, 1.—J. A. Hoogewerff, accompanied by W. S. Eichelberger, Asaph Hall, F. B. Littell.

U. S. Coast Survey, 1.—William Bowie.

The meeting organized by appointing Mr. Hale as chairman and Mr. Stebbins secretary. There followed a general discussion of the present international situation of science, and it was agreed that the Union should take the place of previous international bodies in astronomy.

It was voted that the organization of the Section should be considered temporary until after the proposed conference in Paris in July 1919.

The Section voted that the chair appoint a Committee on Committees, to act temporarily as an Executive Committee, which should consider the general matter of business, appoint all committees, and add additional members to the Section. Appointed: W. W. Campbell, chairman; C. G. Abbot, E. W. Brown, Frank Schlesinger, Joel Stebbins, secretary.

The Committee added the following to the membership of the Section: W. S. Adams, R. G. Aitken, E. E. Barnard, L. A. Bauer, Benjamin Boss, W. S. Eichelberger, W. J. Hussey, V. M. Slipher.

In regard to membership of enemy nations in the Union, the Section voted to adopt as representing the sentiments of the meeting the Declaration of the Interallied Conference on International Scientific Relations, held at the Royal Society in London on October 9 to 11, 1918. (See appendix to this report).

* The following representatives have since been nominated: George David Birkhoff, W. D. MacMillan, R. S. Woodward.

In regard to the admission of neutral nations to the Union, the Section voted that it be the sense of the meeting that nations which had been neutral in the war should be admitted into the International Astronomical Union on the conclusion of peace.

Mr. Schlesinger outlined the kind of astronomical work that requires international coöperation:

First: Work too extensive to be undertaken except by international coöperation; the Carte du Ciel, for example; or the plan of Selected Areas.

Second: Undertakings in which there is a geographical necessity for international coöperation. Variation of latitude; longitudes; variable stars; continuous observation of solar phenomena, etc.

Third: Matters of convention. Uniformity of nomenclature, notation and units. Examples, unit for stellar distances (four now in use); classification of spectra; use of probable or mean error or of average deviation; notation for celestial mechanics; notation for the reduction of photographic plates, etc.

Fourth: The avoidance of duplication. Calculations for the national Almanacs and for special ephemerides, such as comets, asteroids, and variable stars; astronomical abstracts; and news of new comets, variable stars, novae, asteroids and the like.

The Section discussed the various fields in astronomy in which committees should be formed to make report at another meeting of the Section, which would give instructions to the delegates to the proposed Paris conference. The following committees were authorized by the Section. The Executive Committee later made the appointments:

Committee on the Variation of Latitude: F. B. Littell, chairman; A. O. Leuschner, Frank Schlesinger. It was voted to ask the American Section of the International Geophysical Union to appoint a similar committee to confer and make a joint recommendation on the organization and method of handling the work on the variation of latitude.

Committee on Standards of Wave-Length: Henry Crew, chairman; W. S. Adams, Keivin Burns, W. W. Campbell, C. E. St. John.

Committee on Solar Rotation: C. E. St. John, chairman; W. S. Adams, Frank Schlesinger.

Committee on Eclipses: S. A. Mitchell, chairman; E. E. Barnard, H. D. Curtis.

Committee on Stellar Classification: H. N. Russell, chairman; Miss Annie J. Cannon, R. H. Curtiss.

Committee on Asteroids and Comets: A. O. Leuschner, chairman; E. W. Brown, G. H. Peters.

Committee on Almanacs: W. S. Eichelberger, chairman; E. W. Brown, R. H. Tucker.

Committee on Radial velocities: W. W. Campbell, chairman; W. S. Adams, J. S Plaskett.

Committee on Double Stars: R. G. Aitken, chairman; Eric Doolittle, W. J. Hussey.

Committee on Notation, Units, and Economy of Publication: W. J. Humphreys, chairman; E. B. Frost, A. O. Leuschner.

Committee on Meridian Astronomy: Benjamin Boss, chairman; F. B. Littell, Frank Schlesinger.

Committee on Abstracts and Bibliographies: F. E. Fowle, chairman; H. D. Curtis, G. S. Fulcher.

Committee on Research Surveys: G. E. Hale, chairman; F. R. Moulton, Harlow Shapley.

Committee on Stellar Photometry: F. H. Seares, chairman; S. I. Bailey, F. C. Jordan, J. A. Parkhurst, Joel Stebbins.

Committee on Wireless Determination of Longitude: J. A. Hoogewerff, chairman; W. W. Campbell, J. J. Carty. This committee was requested to study the feasibility of deter-

minations of longitude by wireless at widely distributed stations, and report on what seems to be the proper time and method for such undertakings.

Committee on Solar Radiation: Mr. C. G. Abbott was asked to prepare a report on Solar Radiation.

Committee on the Spectroheliograph: The Mount Wilson Solar Observatory was asked to prepare a report on work with the Spectroheliograph.

Committee on Reform of the Calendar: R. T. Crawford, chairman; W. W. Campbell, Harold Jacoby.

The question of delegates to the Paris meeting was left to the Executive Committee with power.

It was voted that the Section offer to act in astronomical matters as the agent of the Division of Physical Sciences of the National Research Council.

Various other items of organization and scientific interest were discussed by the Section at the morning and afternoon sessions, and in the evening, without formal action.

JOEL STEBBINS, *Secretary.*

Declaration in regard to Enemy Nations

When more than four years ago the outbreak of war divided Europe into hostile camps men of science were still able to hope that the conclusion of peace would join at once the broken threads, and that the present enemies might then once more be able to meet in friendly conference, uniting their efforts to advance the interests of science; for ever since the revival of learning in the Middle Ages the prosecution of knowledge has formed a bond strong enough to resist the strain of national antagonism. And this bond was strengthened during the latter part of last century, when branches of science developed requiring for their study the co-operation of all the civilized nations of the world. International Associations and Conferences rapidly multiplied, and the friendly intercourse between the learned representatives of different countries grew more intimate, in spite of their political differences, which were admitted, but not insisted upon.

In former times war frequently interrupted the co-operation of individuals without destroying the mutual esteem based on the recognition of intellectual achievements; peace then soon effaced the scars of a strife that was ended. If to-day the representatives of the Scientific Academies of the Allied Nations are forced to declare that they will not be able to resume personal relations in scientific matters with their enemies until the Central Powers can be re-admitted into the concert of civilized nations, they do so with a full sense of responsibility, and they feel bound to record the reasons which have led them to this decision.

Civilization has imposed restrictions on the conduct of nations which are intended to serve the interests of humanity, and to maintain a high standard, of honour, such as the recognition of the sanctity of treaties—especially those designed to apply to a state of war—and the avoidance of unnecessary cruelties inflicted on civilians. In both these respects, the Central Powers have broken the ordinances of civilization, disregarding all conventions, and unbridling the worst passions which the ferocity of war engenders. War is necessarily full of cruelties; individual acts of barbarity cannot be avoided and have to be borne. It is not of these we speak, but of the organized horrors encouraged and initiated from above with the sole object of terrorizing unoffending communities. The wanton destruction of property, the murders and outrages on land and sea, the sinking of hospital ships, the insults and tortures inflicted on prisoners of war, have left a stain on the history of the guilty nations, which cannot be removed by mere compensation of the material damage inflicted. In order to restore the confidence without which no scientific intercourse can be fruitful, the Central Powers must renounce the political methods which have led to the atrocities that have shocked the civilized world.